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THE COAL-FIELDS OF SCOTLAND

BY · ROBERT · W · DRON

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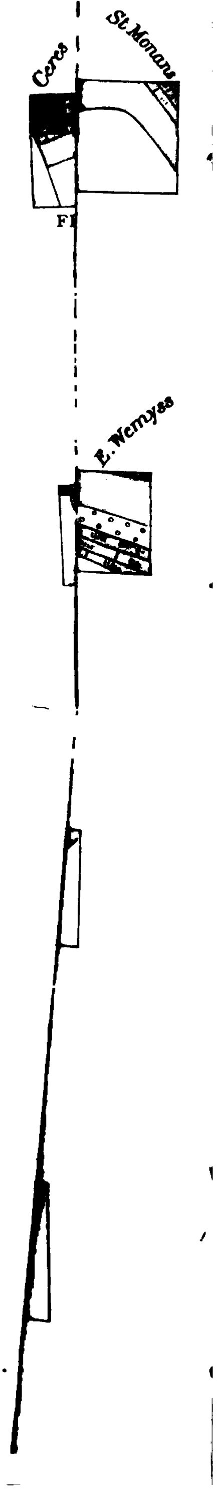
The Coal-Fields of Scotland

PLATE XI



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The Coal-Fields of Scotland

BY

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LONDON
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PREFACE

The object of this work is to present a fairly comprehensive review of the coal resources of Scotland, and of the geological conditions under which the coal-seams and associated strata are found in the various districts.

It is hoped that the information given may be found useful, not only to the student but also to those who are engaged in the practical work of developing our coal-fields.

In preparing the book all available sources of information have been freely utilized, including the publications of the Geological Survey and numerous papers in the transactions of scientific societies. Many records of bores and mineral workings have been placed at my disposal by coalmasters and others, and I have to express my indebtedness for the generosity with which information of this kind has been given. I have received very few refusals to supply any information which would be of general interest and utility. I have also to express my indebtedness to the many friends who have assisted me by revising the descriptions of the districts with which they were intimately associated.

The work of preparing a book of this kind would be somewhat dull and uninteresting if one were not permitted to indulge a little in speculations as to the geological history of the strata and as to the probable condition of the coal-fields which are yet unexplored. It is on this ground that I must crave the indulgence of the reader if I have occasionally ventured too far in the direction of prophecy and conjecture.

R. W. D.

GLASGOW, *April, 1902.*

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The Coal-Fields of Scotland

CHAPTER I

The Carboniferous Formation

The seams of coal and ironstone worked in Scotland are found in a series of basins of the Carboniferous formation which occupies most of the central lowlands, stretching in a belt from the Firth of Clyde in a north-easterly direction to beyond the Firth of Forth.

The area in which the Carboniferous formation was originally deposited may be defined roughly as lying between the Ochil and Lennox Hills, on the north, and the Lammermuir Hills and Southern Uplands of Ayrshire on the south. During the whole of the Carboniferous period this area must have been undergoing a gradual depression —sometimes invaded by the sea, sometimes a freshwater lake or swamp, and at other times marshy land suitable for the luxuriant vegetation from which the coal-seams have been formed.

The subsidence of the sea bottom must have been very slow, and the deposition of sediment from the surrounding land surfaces was usually sufficient to keep pace with it. At times the subsidence was quicker, or the deposition of sediment slower, so that the waters became clear, and in the clear water marine organisms flourished, from which beds of limestone were built up. Again the waters became silted up with mud and sand, which killed off or drove away the limestone builders, and formed sheets of sand and mud over the site.

These conditions of subsidence and deposition continued during the whole of the Carboniferous period until a mass of strata more than 3000 feet thick had been formed. Subsequently a period of elevation set in, whereby the strata were fractured and pushed up in great waves and dome-shaped masses. While the elevation was proceeding, the forces of denudation were wearing away the protruding strata and planing down the inequalities, so that beds which at one time were covered by thousands of feet of strata are now found bare at the surface, and even occupying the crests of hills many hundreds of feet above sea-level. It thus happened that what was once a continuous stretch of stratified rocks has been broken up into many detached basins which now form separate coal-fields.

During the early Carboniferous period, while the waters in Scotland were generally muddy and sandy, the English and Irish area was under clear water most of the time, and enormous beds of limestone were formed on the slowly-subsiding bottom. The beds of limestone formed in Scotland during that period were comparatively thin, from 2 feet to 10 feet being the general limit, although in some exceptional cases a thickness of as much as 100 feet was attained. Tracing the same beds southward into England and Ireland there is found a gradual thinning out of the intervening sandstones and shales, together with a thickening of the limestone-seams. In the north of England and in Ireland the limestone-seams have become solid beds thousands of feet thick, and these are prominently exhibited in the Mountain Limestones of the Pennine Chain. Under such conditions coal-seams were being formed in Scotland at the same time as the beds of limestone were being deposited in England and Ireland. Had the Fates seen fit to place Ireland at this period under muddy and sandy water instead of clear water, what a difference would it have made in the prosperity and development of that country!

During the same period Scotland was also the scene of intense volcanic activity, and great bodies of lava and of ashes flowed over the country, filling up the seas and estuaries, and forming the interbedded igneous rocks characteristic of the Lower Carboniferous.

As originally deposited, the Carboniferous strata probably extended considerably beyond the present limits, especially to the northward. Along the north-western boundary of the coal-field, as it now exists, the Carboniferous strata are occasionally found lying more or less conformably on older strata, but generally they are cut off by a series of upthrow faults running nearly parallel with the Lennox and the Ochil Hills. Those hills are largely made up of great sheets of andesite of Calciferous Sandstone age, interspersed, especially in the western district, with numerous volcanic necks of the same age—necks which now form prominent features of the landscape, such as Dumbarton Rock, Dumbuck, Dumgoyne, and Dungoil.

The south-western boundary is formed by a remarkable line of faulting which has thrown up the Silurian rocks of Kirkcudbrightshire, of the Leadhills, and of the Moorfoot and Lammermuir ranges. At many points this fault exhibits a vertical displacement of at least 10,000 to 12,000 feet. Although, as above mentioned, the coal-fields within those boundaries are now cut up by denudation into a number of separate basins, there can be little doubt that in Carboniferous times they formed one continuous series, extending northward and overlapping the Old Red Sandstones of the marginal highlands.

The Carboniferous series, as developed in Scotland, is subdivided as follows:—

1. COAL-MEASURES,	Upper Red Sandstones. Upper Series of coal seams. Lower Series of coal seams.
2. MILLSTONE GRIT	or Moorstone Rock.
3. CARBONIFEROUS LIMESTONE,	Upper Series of Limestones. Coal-measures. Lower Series of Limestones.
4. CALCIFEROUS SANDSTONES,	Shales, Cementstones, and Sandstones, including the Oil Shale series. Sandstones, Conglomerates, and Cornstones merging into the Upper Old Red Sandstone.

During the periods of the deposition of the Millstone Grit and the Coal-measures, the conditions in England seemed to have been very similar to those prevailing in Scotland at the same time, and thus we find that the Coal-measures of England correspond in productiveness with the (upper) Coal-measures of Scotland. In England the Millstone Grit, which there goes under the name of the "farewell rock", contains no coal-seams of importance, and thus resembles the corresponding formation in Scotland.

It will help better in obtaining a general idea of the present distribution of the various Coal-measures in Scotland if it is kept in mind that at one time the coal-seams both of the upper Coal-measures and the Carboniferous Limestone occupied a continuous area of at least 30 miles in width and 120 miles in length, or altogether 3600 square miles. By subsequent denudation great portions, especially of the upper Coal-measures, have been removed.

The portion of the upper Coal-measures now left only occupies a superficial area of about 720 square miles, and the Limestone measures extend throughout an area of 1680 square miles.

The sections (Plates XIII and XIV) give some idea of how the various measures have been folded into basins and denuded. The processes of denudation and of elevation or folding were more or less contemporaneous, so that at the same time as the rocks were being raised they were also being worn away by denudation.

COAL-MEASURES.—In many parts of the country, as, for instance, in the Hamilton coal-field, a series of red sandstone rocks is found overlying the productive Coal-measures. These rocks belong to the Carboniferous period, and must not be confused with the New Red Sandstones or Permian rocks which form a distinct geological series of a more recent period than the Carboniferous. They never attain a very great thickness, about 600 feet being the maximum, and consist of reddish sandstones, shales, fireclays, and marls, with beds of Spirorbis limestone and occasional thin seams of coal. It very frequently happens that those Upper Sandstones are not conformable with the underlying Coal-measures. This is especially noticeable in Ayrshire, where at certain places the Upper Sandstones overlie both the Coal-measures and the Carboniferous Limestone, and obscure the junction of those measures. Although a certain formation may be found at the surface, such as the Permian or the Upper Red Sandstones, it does not necessarily follow that the next succeeding geological formation will be found underneath. An illustration of this occurs in the Dumfriesshire coal-field. There the Coal-measures are known to underlie the Permian rocks in the eastern part of the Solway basin. If those measures were lying conformable with the Permian, then it might safely be assumed that coal would be found throughout the whole area covered by Permian rocks. But this is not the case, for we find that the Permian rocks are overlapping the Coal-measures, covering their outcrop, and extending westward over older formations. So in some instances the Upper Red Sandstones may be deceptive unless all the surroundings are carefully examined. In the same way there are cases where the Coal-measures are found overlapping the Carboniferous Limestone measures, and resting on older rocks, as, for instance, in the Sanquhar basin, where the Coal-measures are found resting on the Silurian formation without any intervening strata.

In Lanarkshire the Upper Red Sandstones are somewhat extensively quarried, yielding a fairly good stone for building purposes.

Between the base of the Upper Red Sandstones and the first coal-seam of the Coal-measures there is a series of sandstones and shales, with occasional thin bands of coal. Where fully developed this series has a thickness of about 300 feet.

The Coal-measures of Scotland consist of a series of sandstones, arenaceous shales (locally known as faikes), argillaceous shales (locally known as blaes), and fireclay with seams of coal and ironstone. The upper limit of the coal-bearing strata is defined above as the base of the Upper Red Sandstones. The division line between the base of the Coal-measures and the top of the Millstone Grit is, in the western districts, generally taken as a seam of ironstone known in Lanarkshire as the slatey-band ironstone, and in Ayrshire as the black-band ironstone. In the eastern districts the boundary line between these two formations cannot be so clearly defined. The total thickness of the productive Coal-measures strata is generally from 1000 to 1500 feet. In the Lanarkshire district from the base of the Upper Red Sandstones to the top of the Millstone Grit there is a depth of little over 1000 feet, containing about 30 feet of coal. In Ayrshire the Coal-measures strata seldom exceed 800 to 1000 feet in thickness, and in many places they are much thinner, the total thickness of coal varying from 20 to 50 feet. In Edinburghshire the total thickness of the Coal-measures strata is 1200 feet, and the coal contained within this depth amounts to over 100 feet. In Fifeshire the thickness of the Coal-measures amounts to 1500 feet with nearly 80 feet of coal.

During the deposition of the coal-seams the local conditions must have varied very much from time to time. Both in regard to the number of seams and the thickness thereof, the eastern districts have been most favoured, as will be seen from the above figures; but when we come to discuss the various coal-fields in detail, it will be found that, apart from this general variation, there are many local variations. What in one district may be an important seam becomes only a position in an adjoining district, and sometimes whole groups of seams change their character completely in passing from one district to another. It is thus somewhat futile to attempt any exact co-relation of the seams in the different coal-fields. Although, for instance, the Ell Coal of Lanarkshire may possibly at one time have been a continuous seam stretching over the whole area of the Scottish coal-fields, the probability is that during the deposition of this seam the conditions, say, in Ayrshire or in Fifeshire may not have been so favourable as they were in Lanarkshire. Thus, while a coal-seam was being formed in Lanarkshire, shales or fireclays may have been in the course of deposition in the other parts of the Carboniferous area. It is quite feasible, however, to correlate the various groups of seams, although each individual seam may not be found to stretch over the whole area. For instance, the upper group of coals in Lanarkshire, from the Ell to the Virgin, corresponds more or less with the top seams at Leven in Fifeshire and with the upper seams at Kilmarnock: the lower coals of the Clyde basin field, from the Virgin coal to the lower Drumgray, correspond with the seams worked at Kilwinning in Ayrshire, and with the upper seams at Dysart in Fifeshire. In the west of Scotland any seams below the Drumgrays are thin and unworkable, but towards the east there is a remarkable increase in this section, and it is thus found that the group of coals worked in the Shotts, Armadale, and Redding districts, from the Shotts smithy coal to the Colinburn coal, is represented in the western district merely by a thin group of shales and sandstones with bands of coal. On the other hand, these seams are represented in Fife by the rich group of thick coals comprising the lower Dysart seams. As would naturally be expected, the Coal-measures of the Dalkeith field correspond fairly well with the Coal-measures of Dysart and Leven on the opposite side of the Firth of Forth.

THE MILLSTONE GRIT.—Underlying the Coal-measures comes a series of coarse gritty sandstones containing a few very thin seams of coal with beds of fireclay and some bands of ironstone and limestone. The thickness is very variable. In some sections it is absent altogether, and at others it attains a thickness of over 700 feet.

Some attempts have been made to work the ironstone seams found in this deposit.

To the north-east of Carluke two seams of clay-ironstone were at one time worked. The upper seam had a thickness of 5 inches, and the lower varied from a few inches to several feet. Those seams have been traced northward as far as Breich, on the Caledonian Edinburgh and Glasgow Railway, and have also been worked on the other side of the basin between Cumbernauld and Falkirk.

A similar clay-ironstone has also been found in the Millstone Grit to the south of Dollar, and is there known as the Vicar's Bridge ironstone. At the present time those ironstones have no economic importance, but they may be of some use in the future.

There are one or two instances of the occurrence of workable coal-seams in the Millstone Grit, but it is hardly to be expected that such seams will be of good quality. In the Douglas coal-field, at Carmacoup, a seam 4 feet in thickness is found in what is supposed to be the Millstone Grit series. And at Canonbie in Dumfriesshire some coals have been proven in the Millstone Grit underlying the Coal-measures.

The principal mineral of economic value occurring in the Millstone Grit of Scotland is the deposit of fireclay at present being worked at Glenboig and Garnkirk. The section of those seams is as follows:—

	Fms.	Ft.	Ins.
Garnkirk upper working	1	1	7
Strata	7	3	0
Garnkirk under or Heathfield upper working ...	1	5	1
Strata	27	0	0
Gartcosh upper working	0	3	3
Strata	3	0	0
Glenboig upper working	1	2	10
Strata	6	3	0
Gartcosh middle or Glenboig lower working ...	0	1	8
Strata	22	3	0
Gartcosh lower working	0	4	2
Strata	2 to 5	0	0
Carboniferous Limestone Series			

The value of the fireclay lies chiefly in the high proportions of combined silica and alumina.

The following shows two analyses of the clay after calcination:—

Silica	65.41	61.90
Titanic acid	1.33	2.09
Alumina	30.55	32.34
Peroxide of iron	1.70	3.02
Lime	0.69	0.37
Magnesia	0.64	0.20
Potash and soda	0.65	0.36
	100.87	100.28

The specific gravity is 2.6.

The particular property of the bricks made from this clay is, that even though subjected to the intense heat and sudden variations of temperature of a forge-furnace, they do not melt nor splinter. Fireclays, ganister, and some thin coal-seams are being worked from the Millstone Grit series at Castlecary.

A ganister containing as high as 87 per cent of silica is also obtained in this district.

The production of fireclay in Scotland for the year 1900 amounted to 730,964 tons. Of this quantity 330,963 tons came from the county of Lanark, in which the fireclay mines referred to are situated. The average declared value of this fireclay at the pit mouth is about 3*s.* per ton.

THE CARBONIFEROUS LIMESTONE SERIES.—There are three well-defined groups or subdivisions of the Carboniferous Limestone.

1. An upper group of limestones, shales, and sandstones, with one or two seams of coal.
2. A middle group of coals and ironstones, with sandstones, shales, &c.
3. A lower group of limestones, with some ironstone and inferior seams of coal.

This subdivision of the limestones is very useful in tracing that series throughout the different coal-fields. Both the upper and lower group contain seams of marine limestone, which, although thin, are remarkably persistent throughout the whole Scottish area. The upper of these seams is known in the Lanarkshire districts as the Arden, Calmy, or Hirst limestone. This corresponds with the Gair limestone of Carluke district, and the Bluetour limestone of Muirkirk, the Janet peat limestone of West Fife, and probably with the No. 6 limestone of Edinburghshire. There is very frequently a seam of coal of somewhat inferior quality found underlying the Hirst limestone.

The second limestone seam is generally known as the Index limestone, as it forms the base of the first group, and is thus an index of the presence of the coal-bearing strata of the second group. The Index limestone has various local names, such as the Cowglen limestone, and in Edinburghshire the No. 4 limestone. This band of limestone is wonderfully persistent throughout the whole area of the coal-fields.

The principal limestone of the third division is that known as the Hurlet, Main, Bathgate, or No. 1 limestone. In the western districts of Scotland there is generally a coal-seam associated with the Hurlet limestone. To some extent it may be possible to distinguish between the upper and the lower limestones by a comparison of the fossils contained in the seams or associated beds; but, as the great majority of the fossils are common to both series, identification by this means is very difficult and uncertain.

Both the upper and the lower series of limestone beds are being mined and quarried in Scotland.

Formerly they were much sought after for agricultural purposes, but during recent years their principal use has been as a flux in the iron-smelting works, and they are also calcined for the use of builders and plasterers.

The production of limestone from mines and quarries in Scotland during 1900 was 561,778 tons.

The Carboniferous Limestone series also contains many beds of clay-band ironstone and a few beds of black-band ironstone, of which particulars are given in the descriptions of the various coal-fields.

A knowledge of the geological conditions under which the Carboniferous Limestone measures were deposited is of very great importance in connection with the future working of our coal-fields. According to the calculations given on page 331 more than one-fourth of the coal still remaining to work in Scotland is in the seams to be found in that portion of the Limestone series which is concealed under the Millstone Grit and the Coal-measures. In estimating as to the probabilities of finding workable coal in those concealed areas, a consideration of the geological history is necessary in order to arrive at any satisfactory opinion regarding the condition in which the coal-seams were originally deposited.

A general study of the Carboniferous Limestone coals, as found in Scotland, shows that the coal-field may be divided into three distinct districts, in each of which the deposition of the seams has been affected by different conditions. There is, first, a strip from 6 to 10 miles wide running across the country in a north-easterly direction from about Girvan, in Ayrshire, to Elie, in Fifeshire. On the south-east this district is bounded by the great series of faults throwing in the southern Silurian uplands. On the north-west it is bounded by a line of faulting which can be traced first along the north-west of the Girvan valley and at the north-west of Patna. The fault disappears below the Coal-measures of Ayrshire, but reappears again to the north-west of Muirkirk. It there forms the boundary of the Muirkirk and Douglas coal-fields. At Muirkirk the fault throws the Silurians against the Lower Limestones, and to the south of Lesmahagow it throws the Old Red Sandstones against the Upper Limestones. To the east of Lanark the line of faulting becomes obscured, but somewhere in the vicinity of Carnwath it appears to form a junction with another fault running in nearly the same direction from the southern boundary of the Douglas coal-field. The combined faults then continue along the base of the Pentland Hills, and form the north-west boundary of the Edinburghshire coal-field. It is seen at Portobello, on the shores of the Forth; and what may be a continuation of the same fault is found again on the Fifeshire coast, where, after passing through Kilconquhar, it forms the northern boundary of the St. Monans and Pittenweem coal-basins.

In the district between those boundaries the coal-seams of the Carboniferous Limestone series have attained their greatest development.

The number of workable seams, and the total aggregate thickness at various points, is as follows:—

Girvan	6	seams with a	thickness of	31	feet.
Patna	2	"	"	17	"
Mansfield (New Cumnock)	5	"	"	37	"
Muirkirk	8	"	"	47	"
Glenbuck	7	"	"	35	"
Coalburn	8	"	"	37	"
Ponfeigh (Douglas) ...	14	"	"	57	"
Edinburghshire	34	"	"	95	"
Pittenweem	9	"	"	40	"

This shows an average thickness throughout the district of 45 feet of coal.

The remainder of the Scottish area may be divided into two districts by a line running in a north-westerly direction from Carluke to about Kirkintilloch.

In the south-western district, embracing North Ayrshire, Renfrewshire, and portions of Lanarkshire and Dumbartonshire, the coal-seams are very poorly developed. Large areas, such as at East Kilbride and Auchenheath, contain only 2 or 3 feet of workable coal. In the Paisley and Hurlet area a maximum thickness of 16 feet is found; to the west of Glasgow, at Garscube, there is about 12 feet of coal. At Dalry the coal is only about 6 feet thick, and farther south, by Stewarton and Loudoun, the coal-seams are either absent, or very thin and unworkable. Even allowing for the thicker seams at Garscube and Hurlet, the average aggregate thickness throughout does not exceed 5 or 6 feet.

In the north-eastern district, including the eastern portion of Lanarkshire, with Stirlingshire and Fifeshire, the coal-seams are generally better developed than in the south-western district.

The number of seams and the total aggregate thickness at various points in this district are as follows:—

Kirkintilloch	5	seams	with a thicknes of	10	feet.
Denny	2	„	„	6	„
Bannockburn	5	„	„	13	„
Bo'ness	8	„	„	30	„
Fifeshire	12	„	„	46	„

This shows an average thickness of only 21 feet, as compared with 45 feet in the first district. It is also to be noted that there is a progressive thickening of the coals going from west to east.

The Carboniferous Limestone coal areas outside of those three districts are of comparatively little importance.

Scattered throughout the Silurian area to the south-west of the great boundary fault there are numerous outliers of Carboniferous limestone, together with some areas containing Coal-measures and Permian sandstones. There is no doubt that the Carboniferous Limestone series once extended over the greater part of the south-west of Scotland, but the conditions under which it was there deposited were not favourable to the formation of coal-seams.

On the north-eastern margin of the coal-field the conditions are somewhat different from those prevailing on the south-west. Although, as already mentioned, the actual boundary is mostly formed by a series of faults, still the general succession of the beds can be traced downward as we proceed to the north-west from the coal-field.

The lower division of the Carboniferous Limestone series is found in contact with the shales, cementstones, and igneous rocks of the Upper Calciferous, and this series again is lying more or less conformably on the Lower Calciferous and Upper Old Red Sandstones. How far the coals of the Carboniferous series originally extended over the older measures it is impossible to say. There is some evidence to indicate that they may have extended to the edge of the metamorphic schists of the Highlands. If this is a correct assumption, then the area which has been denuded of thousands of feet of coal-bearing strata is greater than the whole area of the coal-fields which are left. It is more than probable that the most of this area was beyond the limits of the Carboniferous sea, but however that may be, if the coals were once there, they are gone now, and there is not very much to be gained by speculations on the subject.

A very important factor in causing the difference between the coal-beds of the western and eastern areas of the Carboniferous Limestone series was undoubtedly the great volcanic activity which, during the Calciferous Sandstone period, had its main centre in the district between Dumbarton and Campsie.

The great sheets of lava which were poured forth at that time, and now form such a prominent feature of the landscape of Renfrewshire and Dumbartonshire, must have had a profound influence in altering the conditions of the early Carboniferous sea or lake. The volcanic centre would also be subject to many local depressions and elevations, even after the active eruptions had ceased. An evidence of this local irregularity of deposition is found in the district of Possil, Kirkintilloch, and Cumbernauld. In tracing the strata throughout that area it is found to be almost impossible to establish an exact correlation between the various seams. For instance, coal-seams found at Possil are non-existent at Cumbernauld, and seams found at Kirkintilloch are not represented in the Possil section. Again, at Kilsyth we find four seams of ironstone, but in the Denny coal-field, just 3 miles distant, there are only two seams of ironstone, and these cannot be co-related with any of the Kilsyth seams. Most of the Kilsyth coal-seams have disappeared altogether at Denny, but some of them come in again farther east at Bannockburn, and the beds of Kilsyth and Bannockburn appear to overlap and dovetail into one another in the neighbourhood of Denny.

A study of the Calciferous Sandstone series, as exhibited between Lesmahagow and Carnwath, shows that there also the bottom on which both this series and the Carboniferous Limestone was deposited was subject to local movements and irregularities. Ample evidence of this is found in the frequent overlaps. For instance, near Auchenheath the Calciferous Sandstones are either absent or are almost entirely covered by the Carboniferous Limestone which overlaps it, and is found resting directly on the Old Red Sandstone. To the east of Lanark the upper group of the Calciferous Sandstone overlaps the lower group, and rests on the Old Red Sandstones. Many similar instances might also be given.

Going farther east, beyond the probable area of the volcanic disturbance, much greater regularity is found. There is little difficulty in tracing the correspondence between the coal-seams of East Stirlingshire, Linlithgowshire, and Fifeshire, and, as already shown, the thickness of the coal is much greater.

The importance of these observations with relation to the study of the concealed areas of Carboniferous Limestone coal is obvious. We have seen how the coal-field may be divided into three separate districts. In the first the total thickness of coal varies from 15 feet to 95 feet, with an average thickness of 45 feet. Wherever these coals pass below the newer formations in that district they may therefore be followed with some reasonable hope of finding workable seams of considerable thickness.

In the second district, that forming the western division of the coal-field, the geological conditions seem to point to considerable irregularity, and the coal-seams are generally few and thin. This indicates that there is much more uncertainty as to the conditions which may exist under the newer measures of that district, and that although attempts will undoubtedly be made to exploit the coal-seams, those attempts will be somewhat speculative. It is a question of great geological and economic interest as to how far the unfavourable conditions of the west have extended into the Carboniferous Limestone series lying below the upper Coal-measures of the Lanarkshire basin.

The somewhat arbitrary division line, running from Carluke to Kirkintilloch, would pass through near Cambusnethan, Bellshill, and Coatbridge, approximately parallel with the course of the River Clyde. This would indicate that the whole of the Limestone series underlying the Clydesdale basin is probably affected by the conditions peculiar to the second district, but that the Carboniferous Limestone coals underlying the Airdrie, Slamannan, and Shotts district belong to the third or eastern division. Throughout the whole of this third district, which includes also Clackmannan and Fifeshire, the seams may not aggregate so great a thickness as in the first district, but they are almost sure to be found in a workable condition, and sufficiently regular to justify their exploitation. If the local circumstances are properly taken account of, sinkings to the lower seams in that portion of the coal-field may therefore be prosecuted with every hope of success. A bore is at present being put down at Tullyallan near Kincardine, through the Millstone Grit series, to prove the underlying Limestone coals. The result of this bore will throw a good deal of light on the subject here discussed.

Before passing from this subject it is worthy of observation that the lower section of the coals of the Coal-measures, *i.e.* the Drumgrays and the underlying seams, are very poorly developed throughout the second district, both in Ayrshire and Lanarkshire; but that they are found of considerable thickness in the first and third districts.

It is an interesting speculation as to why there should be so great a difference in the character of the coal-seams on the two sides of the line of faulting forming the north-west boundary of the first district. This fault—which at

Girvan on the one hand and Muirkirk on the other is of sufficient size to throw the Silurians in direct contact with the Carboniferous—appears to pass through the central basin of Ayrshire without affecting the upper Coal-measures. If this observation is correct, it would apparently indicate that the fault was in existence during the deposition of the Carboniferous Limestone series; so that while a coal-seam may have been in course of formation on the south-east side of the fault, on the north-west the conditions were unfavourable for the formation of coal-seams. While this theory may not meet all the facts of the case, it is difficult to see how else the deposition of coal-seams could have been affected by the presence of a fault.

The officers of the Geological Survey seem to have adopted the same line of reasoning regarding the fault which forms the division line between the coal-fields and the southern Silurian uplands, as shown by the following quotation (Memoir, sheet 15, p. 32):—

"We find that in ascending the Nith valley the Carboniferous Limestone series, which is so well developed in the Thornhill basin, thins out towards the north until, along the south-eastern borders of the Sanquhar coal-field, it disappears altogether, and the overlying Coal-measures come to rest directly on the lower Silurian rocks. No Carboniferous Limestone beds reappear until we reach the great fault, immediately on the north side of which they come in in force. It is difficult to understand how this should have happened, unless on the supposition that at the time when the Carboniferous Limestone series was in the act of deposition, the line of fault was represented at the surface by a steep bank shelving to the north, which formed the limit of the Limestone series on that side, but which as the whole region continued to sink was gradually buried under the continuous sheet of Coal-measures which stretched through the Sanquhar valley northward into Ayrshire."

CHAPTER II

Dumfriesshire

The coal-bearing formations in Dumfriesshire will be considered under three heads. 1st. The Carboniferous Limestone series; 2nd. The Coal-measures and Millstone Grit series; and 3rd. The formations concealed by the Permian and Trias rocks.

The Carboniferous Limestone series of Dumfriesshire forms an extension of the series of Cumberland and Northumberland. It is exposed in a strip about 16 miles long by 3 miles wide, stretching from Newcastleton, on the English border, to the Solway Firth a little west of Annan. The seams of limestone which are found throughout this area are generally of good quality, and have been extensively mined.

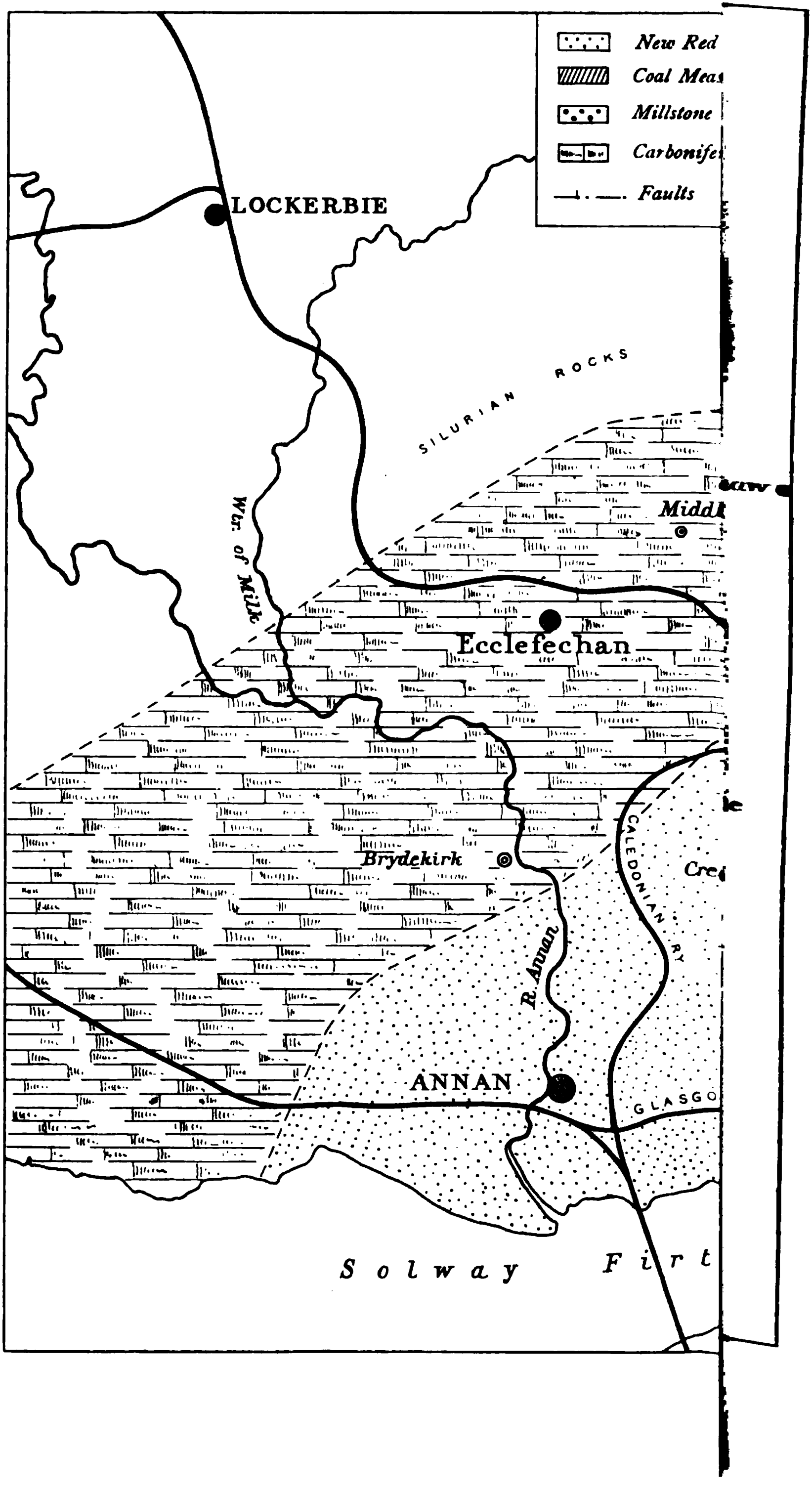
In the year 1900 the output of limestone from Dumfriesshire amounted to 13,600 tons, valued at about 3*s.* 6*d.* per ton. The coal-seams in this series are here very thin and poor, but several attempts have been made to work them for local sale.

At Oakshaw Colliery, about 5½ miles east of the border line, the following section was exposed:—

Section at Oakshaw

	Fms.	Ft.	Ins.
Freestone	1	3	0
Impure limestone	3	3	0
Coal	0	0	4
Shale	2	0	0
Sandstone	6	0	0
Coal	0	0	6
Blue Shale	0	2	2
Sandstone	3	0	0
Blue Shale	1	0	0
Coal	0	1	8
Blue Shale			

GEOL I



New Red
Coal Meas
Millstone
Carbonife
Faults
LOCKERBIE
SILURIAN ROCKS
Wtr. of Milk
Middl
Ecclefechan
Brydekirk
R. Annan
CALEDONIAN RY
Cre
ANNAN
GLASGO
Solway Firt

Mr. Edmund Gibsone, in a paper contributed to the North of England Institute of Mining Engineers in 1862, stated that he had discovered a 5-feet seam of coal at Malsgate, about 2 miles south of Oakshaw Colliery; but there is no record of any attempt having since been made to work that seam.

At Linewater, near the river Liddel, a small colliery worked out a thin seam about 1 foot 6 inches thick, and it is said that there is a 2-feet seam underneath still unworked.

The strata throughout the whole area are very much distorted and crumpled. At Penton Linns, on the river Liddel, some seams of coal from 6 inches to 12 inches thick are found in beds which have been turned up so as to be almost vertical.

Farther west a bore was put down to a depth of 90 fathoms on the Springkell estate, about 3 miles north of Kirkpatrick Station on the Caledonian Railway. One or two coal seams were found in that bore, but nothing that could be considered workable, the thickest being 14 inches.

About 50 to 100 years ago, before the district had been put into railway communication with the neighbouring coal-fields, many attempts were made to find workable seams; but although a few thin seams were worked here and there, nothing of any permanent value was found. As the ground has thus been pretty well explored, it may be assumed that there is not much future prospect of any collieries being established here to work the coals of the Limestone measures.

A few years ago attempts were made to find coal near the shores of the Solway Firth at Rascarrell, near Auchencairn. Coal was worked here to a small extent about sixty years ago. Although several bores were put down, the operations were not successful.

In the Millstone Grit series some coal-seams have been found at Byreburn and Penton, near the village of Canonbie. There are three seams: first, the Main Coal, 3 feet thick; and 4 fathoms below it the Three-quarters Coal, about 2 feet 9 inches thick. About 20 fathoms below the Three-quarters was the Lime Coal, having 20 inches of coal divided by a stone 8 inches thick. Although only a small area of these seams has been exposed near the surface, and they have only been worked to a very limited extent, they are of very great importance as an indication of what may be looked for in the Millstone Grit throughout the area concealed by the Permian rocks.

The extension of the Millstone Grit series under the Canonbie coal-field is referred to later on.

The only colliery now working in the southern district of Dumfriesshire is the Canonbie Colliery, the property of the Duke of Buccleuch. Coals have been worked in this field for over 100 years, and the area available from the present sinkings is nearly exhausted. For future extensions very deep shafts will be necessary.

The section of the present working shaft is as follows:—

SECTION OF CANONBIE COLLIERY

	Fms.	Ft.	Ins.
Strata	22	3	0
Lime Coal	0	3	4
Strata	4	0	0
Musselshell Band	0	0	9
Strata	12	2	0
Main Coal	1	0	0
Strata	13	3	0
Nine-foot Coal	1	3	0
Clay	0	2	0
Coal	0	2	0
Strata	1	2	0
Three-foot Coal	0	3	3
Strata	6	4	0
Five-foot Coal...	0	5	0
Strata	7	1	0
Black-top Coal	0	5	0
Strata	2	0	0
Seven-foot Coal	1	0	0

There is also a seam of coal 1 foot 10 inches thick about 10 fathoms below the Seven-feet Coal, but it has not been worked.

There has been considerable discussion as to the stratigraphical position of those seams, but there is really no doubt that they belong to the (upper) Coal-measures series.

The whole area of Coal-measures exposed at Canonbie is only about 1½ square miles, and this area is very much cut up with faults.

The strata dip about 1 in 5 towards the south-east.

A diamond bore was put down from the pavement of the Seven-foot Seam in 1891, with the view of ascertaining if the Millstone Grit coals of Byreburn and Penton extended beneath the Canonbie field. In that bore fourteen thin seams of coal were met with, the thickest being 2 feet 4 inches at a depth of 193 fathoms below the Seven-foot Seam. The bore was continued 32 fathoms farther, and met with several beds of limestone, thus showing that it had passed through the whole of the Millstone Grit series.

On the south and south-east the coal-field is bounded by a large downthrow fault apparently over 200 fathoms in extent, which throws in the Permian measures.

On the north-east it is cut off by an upthrow fault which throws the Millstone Grit to the surface, and on the north-west the Coal-measures crop out, and are succeeded in natural course by the Millstone Grit and Carboniferous Limestone series.

The nearest coal-field to Canonbie where coals are being worked in the Coal-measures is in West Cumberland, about 23 miles distant. In order to show the relation between the seams as found in Cumberland and the Canonbie seams the following section at Bullgill Colliery, on the Carlisle and Maryport Railway, is given:—

SECTION OF BULLGILL COLLIERY (CUMBERLAND)

	Fms.	Ft.	Ins.
Ten-quarters Coal	1	0	8
Strata	5	5	4
Rattler Band Coal	0	2	10
Strata	0	3	8
Slatey-band Coal (with partings)	1	1	0
Strata	1	4	3
Coal	0	1	0
Strata	8	3	3
Thirty-inch Coal	0	3	0
Strata (with ironstone bands)	1	2	6
Metal-band Coal	0	5	6
Strata	1	4	0
Cannel-band Coal	1	2	0
Strata	6	0	0
Coal	0	1	0
Strata	3	3	0
Yard-band Coal...	0	3	0
Strata	13	3	0
Brassy Coal	0	3	6
Strata	4	0	0
Little Main Coal	0	2	0
Strata	5	0	0
Eighteen-inch Coal	0	1	6
Strata	5	0	0
Lickbank Coal	0	1	10
Strata	2	0	0
Six-quarter Coal (with partings)	1	1	6
Strata (with ironstone bands)	11	0	0
Coal	0	1	4
Strata (with ironstone bands)	4	0	0
Coal	0	1	5
Strata	7	0	0
Ironstone	0	1	1

From the Ten-quarter Seam to the Six-quarter Seam this section shows twelve seams which have been worked, giving an aggregate thickness of 48 feet 10 inches of coal. The Canonbie section shows 37 feet 7 inches of coal in seven seams. An exact correlation of the seams is hardly possible, but probably the Lime Coal corresponds with the Ten-quarters and the Nine-foot, and Three-foot Coal correspond with the Metal and Cannel-band seams.

In the Bullgill district there is 80 fathoms of strata above the Ten-quarters Seam, and in this depth there are ten or twelve thin seams of coal ranging from 6 inches to 1 foot 4 inches, but no workable coals are found. The Lime Coal of Canonbie is thus probably the highest coal in the series, and there does not appear to be evidence of any upper seams which might have been removed by denudation.

That the coal-field of Canonbie was once coterminous with the Cumberland coal-field seems to be beyond doubt. The whole area, from Aspatria, in Cumberland, to the boundary of the Canonbie field, is now covered with Permian and Triassic rocks, and the outcrops of the coals are thus concealed under a deposit of from 100 to 200 fathoms of those rocks. To what extent the Coal-measures may have been denuded before the deposition of the Permian is a question which will only be solved by bore-holes and coal-workings. Bore-holes were put down in Netherby estate, 1 mile south of Canonbie, about forty years ago, but they were not carried beyond 120 fathoms, and therefore did not pass through the Permian beds.

In 1889 a bore-hole was put down in about the same position to a depth of 263 fathoms.

The Red Sandstones were found to be 190 fathoms thick, then fourteen thin seams of coal were met with. At 257 fathoms a coal 2 feet 5 inches thick was cut, and 5 fathoms below this a mussel-bed 10 inches thick, and the bore was not continued farther.

In the section worked at Canonbie there is only one mussel-band found, namely, the 10-inch bed, at 4 fathoms below the Lime Coal. The above seam may therefore be identified with the Lime Coal, but this cannot be affirmed with any degree of certainty.

From Canonbie southward to the Solway Firth there is a total area of about 80 square miles covered by the New Red Sandstones.

It is not to be supposed, however, that there is a continuous coal-field underlying those measures and stretching southward into Cumberland.

In the period between the formation of the coal-seams and the deposition of the Permian there must have been extensive movements of the strata. The crumpling and distortion of the Carboniferous Limestone took place before the comparatively level beds of the Permian were deposited. The Coal-measures do not seem to be lying conformable with the Limestone series, and probably the limestones had been considerably distorted before the Coal-measures period began, so that we would not expect to find so much disturbance of the Coal-measures as there is of the Limestone measures; but that there were considerable movements affecting both the Coal-measures and the Limestones is evident from the unconformability between the coal-seams and the Permian strata. During those movements denudation would take place, and the outcrops of the coal-seams would be planed down and washed away, so that before the Permian period the coal-field was probably cut up into various separate basins. The bore mentioned above has proven that the Coal-measures still exist in at least the north-eastern part of the area. How far they extend westwards it is at present impossible to say. That they do not underlie the whole basin is proven by the fact that the Limestone measures are found cropping out along the north-western margin, as shown on the map, Plate I, and the Coal-measures must therefore terminate at some point beneath the Permian covering.

While an exact estimate of the extent of this field is therefore impossible, some idea of its importance as a reserve for future working may be obtained if we assume that the Canonbie seams will be found underlying one-fourth of the area of Permian rocks, *i.e.* throughout 20 square miles.

Taking 35 feet thickness of coal shows a quantity of 420,000,000 tons which may possibly be available. The Royal Commission on Coal estimated that 150,000,000 tons might be found, but of course, with our present knowledge, any estimates of this kind are purely guess-work. They seem, however, to demonstrate that this area is worthy of the serious attention of coal-masters.

In the sinkings, in England and on the Continent, through Permian strata very large quantities of water have been met with, involving a great outlay for shaft tubbing. It is worthy of note that the Permian beds of Dumfriesshire contain a considerable proportion of clays interstratified with the sandstones, with the result that the strata are comparatively free from water. No doubt water will be met with in sinking, but in all probability the quantity will not be excessive, and the intervening beds of impervious clay will probably make it more easily dealt with.

There are several other areas in Dumfriesshire covered with Permian deposits, notably in the valley of the Nith at Dumfries and at Lochmaben, but as those deposits are everywhere resting on the Silurians there is no reason to expect that they cover any Coal-measures.

It is possible, however, that there may be some Carboniferous Limestones underneath the Permians of Dumfries, as those Permian rocks contain some beds of calcareous breccia, locally known as "brockram", principally derived from the waste of Carboniferous Limestone; but even though there may be some remnants of the Carboniferous Limestone series, the prospect of finding any coal is very remote.

Farther north, in the Thornhill basin, a series of rocks is found cropping out from below the Permians, and these have been classed by the Geological Survey as belonging to the Carboniferous Limestone period. There is, however, no evidence of the existence of any coal-seams, and there is no reason to hope that any workable coal will be found in that district.

There are various outliers of the Carboniferous Limestone scattered throughout the Silurian uplands of the northern part of Dumfriesshire and south-west Lanarkshire.

Those outliers demonstrate that the Carboniferous Limestone measures once extended over a great part of the south-west of Scotland, but they have since been removed by denudation, with the exception of the outliers mentioned. The denudation probably took place at the same time as the Coal-measures and the Permians were being deposited on the adjoining areas. In the little patches which are left there are no coal-seams of any economic importance.

At Whitecleuch, in the Duneaton valley, there is an outlier of Carboniferous Limestone about 400 acres in extent. The M'Donald Coal, the lowest of the Muirkirk series, has been worked here to a small extent, and possibly some of the other Muirkirk seams may also be found and will be worked if there is ever a railway communication.

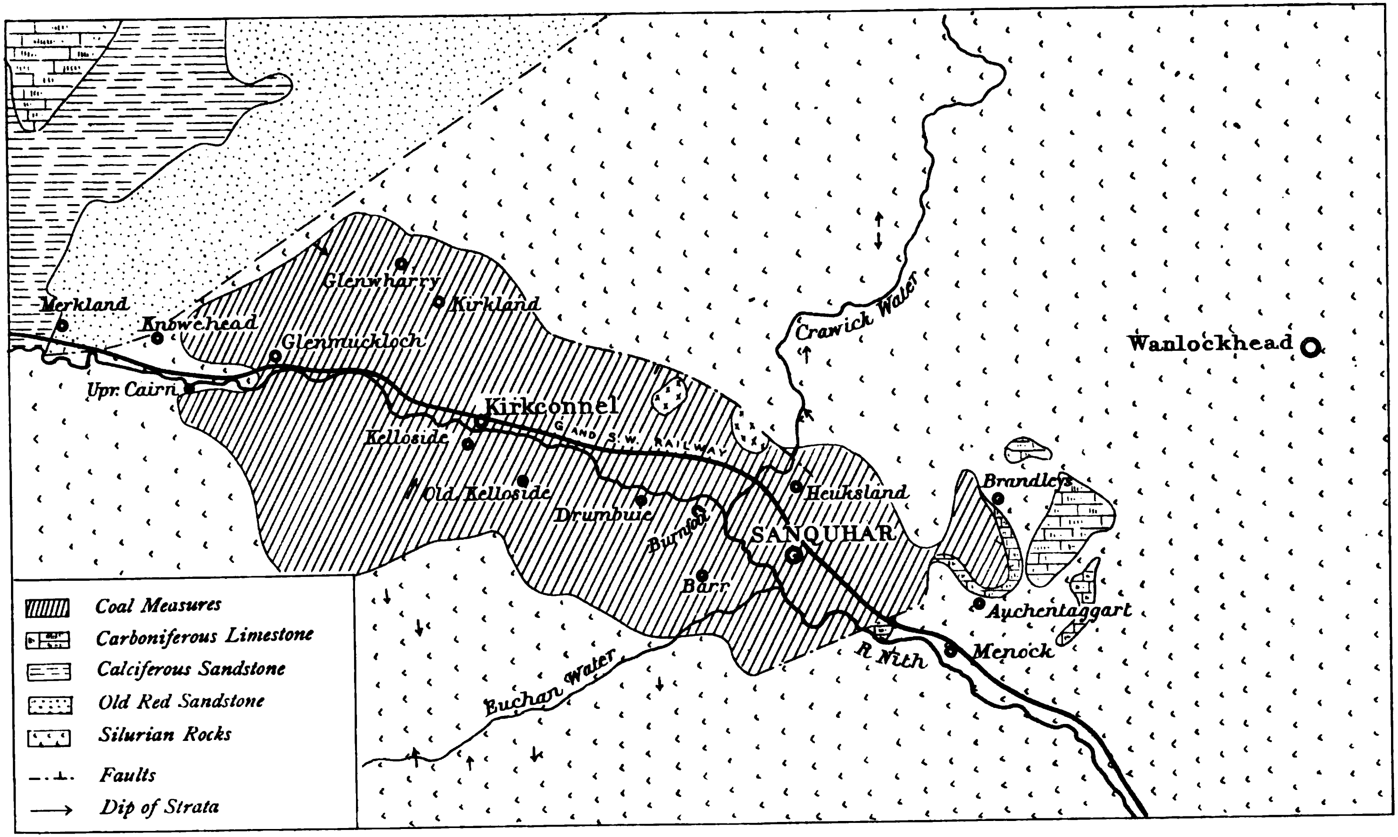
At Sanquhar and Kirkconnel there is an important coal-field containing about 17 square miles of the Coal-measures. This basin is a southern extension of the New Cumnock coal-field, from which it is separated by about 3 miles of Silurian and Old Red Sandstone rocks. On the south-western margin the Coal-measures are resting directly on the Silurians, and the seams dip towards the north-east. Along the north-eastern margin of the coal-field there is a deposit of the barren Red Sandstones lying unconformably on the Coal-measures. These sandstones were deposited after the Coal-measures had been tilted up at the south-west, and are probably composed of the sands which have been denuded from the Coal-measures area, and represent the site of an ancient lake.

The section of the coals at Kirkconnel is as follows:—

	Fms.	Ft.	Ins.
Creepie Coal, {Coal, 32 inches Daugh, 8 „ Coal, 16 „}	0	4	8
Strata	6	0	0
Calmstone Coal (including four Daugh partings)	0	5	0
Strata	6	0	0
Twenty-inch Coal	0	1	8
Strata	30	0	0
Splint Coal	0	4	3

GEOLOGICAL MAP OF SANQUHAR COAL-FIELD Scale—2 miles to an inch

PLATE II



In the Geological Survey section another seam, called the Daugh Coal, is shown between the Splint Coal and the Twenty-inch Coal. Subsequent developments have shown that the seam which was called the Daugh Coal at Kirkconnel is really the Creepie Coal, which was there found as a seam 2 feet 4 inches thick without the daugh in the centre.

Near Sanquhar the Geological Survey have shown a seam as the "Daugh Coal", but that seam is now believed to correspond with the Splint Coal of Kirkconnel. Underlying the Splint Coal there are several thin seams which have not yet been proved except at the outcrops.

The Calmstone Coal is of good household quality, resembling the Ell Coal of Lanarkshire. The Splint Coal is not unlike the Lanarkshire splint, both in quality and appearance.

This coal-field is very much troubled, both with faults and intrusive whinstone. The general trend of the faults is from north-west to south-east, running across the basin at a flat angle. There are several intrusive dykes, running at about the same angle, and from those dykes intrusive sheets have invaded the coal-seams, and destroyed them over considerable areas. The whinstone, when in contact with the coal, is frequently altered into "White Horse". The Geological Survey have indicated the position of five volcanic necks in this area. These are similar to the necks found in Ayrshire, and affect the coal-seams in the same way.

A peculiar trouble affects a large area of the splint coal workings at Bankhead. In the area referred to, the bottom portion of the seam is shattered and broken into dross, apparently caused by a movement of the pavement. The top portion of the coal is quite intact, and the roof does not seem to be affected in any way.

The seams worked at Sanquhar appear to correspond with the coals of New Cumnock, underlying the Lower Gas Coal, the Creepie Coal being probably equivalent to the New Cumnock Eight-foot Coal. None of the seams contain the Cannel Coal, characteristic of the Upper and Lower Gas Coal seams of New Cumnock.

I am informed that some coal-seams have been found at the northern end of the field, and the local opinion is that these may possibly correspond with the Lanemark Cannel Coals. One of them is a free coal, 5 feet thick, with a shale or gas coal on the top, about 18 inches thick, of fairly good quality. There is supposed to be another seam below this, also containing cannel coal. Those seams appear to lie about 90 fathoms below the splint coal, but no systematic attempt has yet been made to prove their position or quality.

To the east of Sanquhar there are some exposures of the Carboniferous Limestone series, but no coal-seams have been found there. It is possible that the Carboniferous Limestone series may also exist to some extent underneath the north-eastern portion of the Sanquhar coal-field. On the south-western side of the basin the Coal-measures, as above mentioned, are lying directly on the Silurian schists. This may, however, be an overlap, as shown in the illustration (fig. 1).

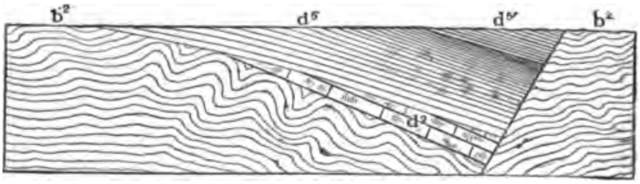


Fig. 1.—Section to illustrate Structure of Sanquhar Coal Basin
b^2, Silurian rocks. d^5, Coal-measures. $d^{5'}$, Upper sandstone. d^2, Carboniferous limestone.
The Carboniferous limestone has not been proven, but may exist as shown in this section.

In any case the extent of the Carboniferous Limestone measures here must be very limited, and the prospects of finding any workable coal-seams are practically *nil.*

The whole of the Sanquhar coal-field is situated on the property of the Duke of Buccleuch, and is let under a long lease to Mr. James Irving M'Connell of Sanquhar.

The principal working pits are at Fauldhead, Kirkconnell, and these have recently been deepened and fitted with modern coal-cleaning plant. Work is also being carried on at Gateside, near Sanquhar.

There is no chance of finding coal in Dumfriesshire outside of the areas already indicated. The occurrence of Permian strata at various points has led to the supposition that coal might be found underneath; but a study of the geological conditions under which those beds were deposited clearly demonstrates that they have been laid down either directly on the Silurian rocks, or in some cases on strata belonging to the lowest section of the Carboniferous period, in which no coal-seams are found. At places the Silurian rocks contain black shales, which somewhat resemble the shales of the Coal-measures, and this has led to several attempts to find coal. It is hardly necessary to say that those attempts have been quite unsuccessful.

Veins containing lead, silver, and even gold have been discovered and worked in those Silurian rocks, and also veins of antimony, but a description of these does not enter into the province of the present work.

CHAPTER III

Ayrshire Coal-Field

I. The Carboniferous Limestone Measures

District of Glenbuck and Muirkirk.—Two important events in the history of the coal and iron trades are associated with the Muirkirk district. One of the first blast-furnaces in Scotland was erected at Glenbuck in the year 1792, and the ruins of this furnace are still in evidence.

The first attempt to manufacture coal-gas on a commercial scale was made at Muirkirk a few years later, the gas being used to light workshops at the furnaces.

In the little basin of the Glenbuck and Muirkirk coal-field all the sections of the Carboniferous series, from the Coal-measures to the Calciferous Sandstone are represented. Adjoining the coal-field, or in the near vicinity, are found the older formations of the Old Red Sandstone and the Silurians, while the surface presents many traces of the recent Glacial period; so that within a radius of a few miles there is a whole text-book of geological history, showing many different epochs in the formation of the earth. In the coal-field, also, there are numerous examples of igneous rocks, indicating former volcanic activity; and of faulting, showing great distortions of the earth's crust.

The eastern boundary is formed by a fault running north and south, and of sufficient size to throw the Old Red Sandstone into contact with the Millstone Grit. From this boundary the coal-field stretches in a south-westerly direction for a distance of about 7 miles, until it is cut off by another fault about 3 miles west of Muirkirk. The general form of the coal-field is a trough or syncline, with the Millstone Grit in the centre. The Limestone measures are found cropping out on either side at an inclination of from 20° to 30°. At the western boundary, near Wellwood, the Upper Coal-measures are found in the centre, overlying the Millstone Grit.

At Glenbuck the trough is barely a mile wide, but towards the west it becomes deeper and broader, until, at the western boundary, it is over 2 miles wide. This is due to a series of faults running at about right angles to the strike, or line of level course, by which the coals are thrown down in successive steps. The largest of these faults has a throw of about 60 fathoms. As is frequently the case in a coal-field of this structure, faults running parallel with the line of strike are seldom met with.

The coals are also very much disturbed with intrusive igneous rocks. These take the form of sills or "floats", and dykes. In many cases the position of one or more of the seams is taken by these floating whins, and in that case the whin is generally altered into a soft white rock, known to the miners as "White Horse". There are also a number of the volcanic necks, so frequently found in the Ayrshire coal-fields.

The section at Muirkirk is as follows:—

	Fms.	Ft.	Ins.
Millstone Grit	140	0	0
Bluetour Limestone	8	4	0
Bluetour Coal	1	2	0
Strata	10	0	0
Limestone	0	2	0
Strata	15	0	0
Tibby Pagan s Limestone	1	0	0
Strata	12	0	0
Cokeyard Coal	0	3	6
Strata	13	0	0
Limestone	0	4	0
Strata	8	0	0
Limestone	0	1	3
Strata	5	0	0
Ell Coal Limestone (Index)	0	2	3
Strata	6	0	0
Ell Coal	0	4	0
Strata	0	4	0
Black-band Ironstone	0	0	10
Strata	6	0	0

	Fms.	Ft.	In.
Seven-foot Coal	1	5	2
Strata	5	0	0
High-band Ironstone	0	1	2
Strata	5	0	0
Mid-band Ironstone	0	1	3
Strata	1	0	0
Thirty-inch Coal	0	2	6
Strata	5	0	0
Six-foot or Catchyburn Coal	0	4	6
Strata	8	0	0
Low-band Ironstone	0	1	0
Strata	2	0	0
M'Donald Coal	0	5	0
Strata	0	2	0
M'Donald Ironstone	0	1	2
Strata	2	0	0
Lower Limestones			

The Ell Coal Limestone in this section is the Index Limestone of Lanarkshire, and the Bluetour Limestone and Coal is the Calmy or Arden Limestone.

The ironstones are mostly clay-band, and were extensively worked when the cold-blast process was in use at the furnaces.

Towards the east the Seven-foot Coal splits up into two seams, known at Glenbuck as the Three-foot and Four-foot Coals, with about 5 fathoms of strata between them. At Glenbuck there is also another seam, 8 feet thick, 3 fathoms above the High-band Ironstone.

None of the Muirkirk coals are of a high quality, but they are very suitable for the purpose to which they have been mostly applied, viz. the smelting of iron ores. The M'Donald coal, however, is very inferior, containing a large amount of iron sulphurets or "brasses", and can hardly be considered a workable subject. At Glenbuck it has the expressive name of the "stinking coal". The Thirty-inch Coal has hardly been worked at all, mainly on account of its thinness. Its quality is fairly good. All the other seams have been extensively worked, and are now approaching exhaustion. The most profitable seams are the Three-foot Coal at Glenbuck and the Nine-foot Coal

both at Glenbuck and Muirkirk, on account of the bands of rich cannel coal which they contain.

The following sections show the position and thickness of the cannel bands:—

THREE-FOOT SEAM

	Ft.	Ins.
Coal	1	3
Gray Fakes	0	8
Horney (Inferior Gas Coal)	0	4
Coal	1	8
Gas Coal	0	5
Coal	1	0
Daugh	0	2

NINE-FOOT SEAM

	Ft.	Ins.
Head Coal	1	6
Coal	0	4
Gas Coal	0	11
Coal	0	6
Fireclay	0	1½
Coal	1	4
Fireclay	0	2
Coal	1	4

The Six-foot or Catchyburn has not been so extensively worked as the other seams. A little gas coal has occasionally been found in this seam, but not sufficient to make it worth while working as long as the other seams were available.

An analysis of one of the Glenbuck gas coals, by Dr. William Wallace of Glasgow is here given:—

Volatile matters	Gas, Tar, &c. ...	47.45	50.9
	Sulphur	.10	
	Water at 212° F. ...	3.35	
Coke	Fixed Carbon ...	46.42	49.1
	Sulphur	.14	
	Ash	2.54	
	Specific gravity ...	1.209	

Practical Results

Gas, per ton of Coal, at 60° F. and 30 inches Barometer...	11,680 cubic feet
Illuminating power in Standard Sperm Candles	32.71

A seam of very rich Boghead gas coal, 7 inches thick, has also been worked to a limited extent at Glenbuck. This seam is 6 fathoms above the Three-foot Coal.

The only portion of the Muirkirk coal-field which has not been thoroughly developed is a strip about 2 miles long, lying to the west of Muirkirk, and separated from the Glasgow and South-Western Railway by the river Ayr.

GASS WATER, GUELT, AND NEW CUMNOCK.—Several outliers, or detached basins, of Limestone measures are found scattered throughout the district lying to the south of the Muirkirk coal-field. Farther west these measures are again seen forming the eastern fringe of the southern Ayrshire coal-field, and are dipping below the Millstone Grit and the Coal-measures. The coal-seams of the Carboniferous Limestone series have been worked at Guelt, or Grievehill, to the north-east of New Cumnock, and at Gass Water, about 5 miles farther north. They have also been worked at Sorn village, on the banks of the river Ayr.

At Guelt the coals were of remarkable thickness, as shown in the following section:—

SECTION AT GUELT OR GRIEVEHILL

	Fms.	Ft.	Ins.
Clay Gas Coal	0	1	8
Strata	1	4	0
Nine-foot Coal	1	3	0
Strata	2	4	0
Eleven-foot Coal	1	5	0
Strata	2	0	0
Twelve-foot Coal	2	0	0
Strata	1	3	0
Three-foot Coal	0	3	0

The seams occupied a narrow trough. At one point known locally as "Noah's Ark" they had been bent completely round into the form of the letter U. At the same time the strata between the seams had thinned out so that the coals had come together in a form which naturally suggested the above name. This "ship" was quarried out about sixty years ago. The coals are said to have been of very good quality, and they were carted as far as Muirkirk and Sanquhar. The Clay Gas Coal was a brown coal which, from the description given to me by one who had worked there in his youth, must have been of exceedingly good quality. There was also a band of gas coal in either the Eleven-foot or the Twelve-foot Seams, but tradition is somewhat hazy on this point.

The old workings are somewhat extensive, and several of the mines are still open. The coal is very hard and splinty, as is shown by the fact that the old stoops, although they have been exposed to the atmosphere for sixty years, are still standing just as the old miners left them.

One of the mines which I examined this year (1901) was in a seam about 9 feet thick, which had been worked on the old-fashioned stoop-and-room system. The roof must have been very good, because although the stoops were small and the places wide there were very few falls. The seam is dipping with a gentle inclination towards the north-west.

At Gass Water the section as given by the Geological Survey was somewhat different.

SECTION AT GASS WATER

	Ft.	Ins.	Fms.	Ft.	Ins.
Limestone			1	0	0
Strata			3	1	6
Limestone			0	1	6
Strata			2	0	0
Limestone			0	5	0
Coal	2	6	2	4	3
Strata	2	2			
Coal	2	4			
Stone	0	10			
Coal	0	9			
Stone	0	9			
Coal	3	0			
Stone	0	6			
Coal	1	3			
Strata			8	0	0
Coal			0	2	0
Strata			0	1	2
Coal			0	1	3
Strata			1	0	0
Smithy Coal			0	1	8
Strata			3	0	0
Clay Ironstone			0	0	10
Strata			1	3	0
Coal			0	2	0
Strata with Ironstone			1	2	0
Coal			0	1	0
Strata			3	0	0
Limestone			1	5	7

I have been unable to find if there was gas coal along with any of these seams. A comparison of the sections of Guelt and Gass Water with those at Sorn and Muirkirk proves that the conditions under which the Limestone measures were deposited in this locality must have been somewhat irregular. It may be suggested that there is some connection between this local irregularity and the formation of the bands of gas coal. The coal-seams must have been deposited in small lagoons, probably separated from one another by land surfaces from which the streams were bringing down drifted vegetation, containing the ingredients necessary to form the cannel coal. It is an interesting subject for enquiry, but not a subject which we can enter into here.

The country between Gass Water and Guelt should contain a continuation of these coal-seams.

In the memoir of the Geological Survey which was published thirty years ago the following statement is made:—"The quality and thickness of some of those coals have induced a rigorous search for the reappearance of the seams, but hitherto without success owing to the borings having been conducted too near the edge of the basin, and consequently through lower rocks. A series of bores properly conducted along a line from High Polquheys to Laigh Glenmuir would probably discover them, though the character of the coals would be found to differ from their representatives at Edgehill (Guelt), as at Dalfad and Gass Water, where they are known to exist, they have varied considerably."

Some attempt was made to work these coals in 1873, but no properly directed effort has ever been made to find the Guelt coals on the lines indicated by the Geological Survey. This is probably accounted for by their isolated position at an elevation of 400 feet above the railway. Some recent borings were made to the coals at Gass Water, but the result was not satisfactory, and no attempt was made to open them up with pits, although quite accessible to the old branch railway.

Along the southern border of the New Cumnock coal-field the Carboniferous Limestone measures are seen cropping out in a narrow strip lying against the great boundary fault. If, as before remarked (p. 17), this fault represents a shore-line which was in existence during the deposition of the Carboniferous Limestone series, it is hardly to be expected that coal-seams will be found in its immediate vicinity. Under these circumstances it is not surprising that in a bore put down at Mansfield, near New Cumnock, a point about 1 mile from the boundary fault, no workable coal-seams were found. The Guelt coals are 2¼ miles from the fault. Farther west, in the Dalmellington coal-field, the Limestone coals have been worked at a distance of about 3 miles from the fault, but boring seems to prove that in the intervening area the coals are not in a workable condition. In this connection it may also be noted that the Limestone measures which occur at the south of the Glespin coal-field approach within about a mile of the boundary fault, and borings there have shown a similar absence of coals. Judging from this evidence an opinion might be hazarded that, where the Limestone measures are concealed beneath the Upper Coal-measures of New Cumnock and Dalmellington, it is very probable that they will be barren in a strip along the fault 1 to 3 miles wide. Beyond this strip the Carboniferous Limestone series should be as productive as it is at Patna or Muirkirk.

At Benston, a little to the north-west of New Cumnock, a limestone, corresponding probably with the Bluetour, or Upper Limestone, was worked many years ago. The old workings are still open, and it can be seen that the strata are lying in the form of a flat saddle, with a slight dip either way to north and south. The great sheet of intrusive whinstone which comes to the surface in the railway cutting between Old and New Cumnock, and forms the hill to the east of the railway at Avisyard, underlies the Benston limestone, but there is no evidence to show whether it has affected the coals which may be underneath it. A bore at Benston found the whin at 24 fathoms deep, and was stopped at 74 fathoms still in whinstone. This whinstone at its outcrop appears to be above the position of the Guelt and Gass Water coals.

There can be no doubt that the Limestone measures continue underneath the Upper Coal-measures of Cumnock and Dalmellington, and it is a very interesting question whether any of the coal-seams will be found at a workable depth, and in a workable condition. The probable depth may be estimated by taking the distance from the Black-band Ironstone to the first seam of the Limestone series, as found at Muirkirk and at Patna. The average distance is approximately 200 fathoms, so that a pit or bore put down any place near the outcrop of the Black-band Ironstone should reach the lower seams at a depth of 200 fathoms. Over a large area of the New Cumnock and Dalmellington coal-field the Black-band Ironstone is found very near the surface, so that there seems to be a reasonable prospect of finding here a very large field of coal at a workable depth.

SORN COAL-FIELD.—Going farther north the Limestone measures are seen dipping under the Lugar coal-field at Aird's Moss, but they are again thrown to the surface by a large east-and-west fault running along near the south bank of the River Ayr. This fault forms the southern boundary of an area of Carboniferous Limestone measures which stretches in a strip about a mile wide along the valley of the Ayr River for a length of about 3 miles, forming the Sorn coal-field. This coal-field is bounded on the west by the overlapping sandstones of the Upper Coal-measures, which probably conceal a large fault between Sorn and Catrine. There is also a northerly extension of this coal-field over Grange Muir. One or two thin seams of coal are seen cropping out on the banks of the River Ayr to the east of Sorn village, but the strip which is exposed is so narrow and so much troubled that it is impossible that there can be any appreciable quantity of coal here. Several old pits can be seen on the south bank of the river near Sorn. The only record I have been able to find of these workings is in Sir John Sinclair's *Statistical Account of Scotland* (vol. xx, p. 153), in which it is stated that a pit here was working the following section in the year 1797. "The main seam is here 8 feet thick, with 6 inches of fireclay in the middle. Immediately above this seam there is a stratum of the same kind of clay 18 inches thick; above this 18 inches of coal, then 20 inches of hard black slate, and over that near 3 feet of coarse coal." That is 12 feet of coal and 3 feet 8 inches of dirt.

The writer of this record, Mr. Farquhar Gray of Gilmillscroft, says: "The stratum of till with 10 feet of blaze over it makes a good roof, and allows us to work the mine from 16 to 20 feet wide, leaving pillars from 18 to 20 feet square. When I entered upon this work the wages of the workmen both above and below were 9*d.* to 14*d.* per day. They are now from 14*d.* to 2*s.* The field is very irregular below, having many steps throwing the coal up and down, a circumstance which increases the expense of working it. My present working pit is 30 fathoms deep, and driven by a horse gin. By a memorandum in our charter books, it appears that, ever since the year 1423, the standard Gilmillscroft coal creel was 14 inches wide, 16 inches deep, and 30 inches long within. It further adds that the coal had been wrought in the Burrowlands since the year 1497. We continue nearly the same measure for half a load sold at 3*d.*, of which about 7 load make 20 cwt." The present collier's wage of 7*s.* per day (1901), with a selling price of 8*s.* to 10*s.* per ton, compares very favourably with the 1797 rate of 1*s.* 2*d* to 2*s.* per day, with a selling price of coal at 3*s.* 6*d.* per ton.

About thirty or thirty-five years ago there was a working for splint and gas coal at Dalgain, about half a mile north of Sorn. The coal-field opens out here to a width of about a mile and a half, and there seems to be a fair prospect of finding valuable seams. The pit at Dalgain was only worked to a very small extent, principally for the gas coal. There is no railway communication, and the coal had to be carted to Mauchline, about 4 miles distant. The section of the Dalgain pit, as given in evidence recently before a Parliamentary committee, was as follows:—

SECTION OF DALGAIN PIT, SORN

	Fms.	Ft.	Ins.
Surface, ...	2	0	0
Limestone, ...	1	0	0
Fakes, ...	0	1	0
Kingle, ...	0	1	3
Sandstone, ...	0	4	0
Coal, ...	0	0	6
Sandstone, ...	2	2	0
Caulm, ...	1	0	0
Dross Coal, ...	0	1	8
Gas Coal, ...	0	1	4
Sandstone, ...	0	4	6
Splint Coal, ...	0	3	0
Sandstone, ...	0	2	0
Splint Coal, ...	0	4	6

The workings were in the splint coal 4 feet 6 inches thick, and mines were driven up to work the gas coal.

The Limestone here is probably the Index Limestone, and the gas coal, which was reputed to have been of very good quality, seems to correspond with the Boghead gas coal found at Glenbuck (p. 33), and also with the Clay Gas Coal of Guelt.

There are signs of old workings on Grange Muir, about 2½ miles north of Sorn, and in the *Statistical Account of Scotland* the seam worked here is stated to have been 5 feet thick, and lying very near the surface. I can find no corroboration of this statement, and the thickness is probably overstated. It is to be noted that the Limestone measures at Grange Muir are to the north of the line of faulting described on p. 11, and they are in the impoverished condition common to the rest of the Limestone measures in Ayrshire north of that fault.

What may be described as a continuation of the Limestone measures of the Sorn coal-field is found in a narrow strip around the northern margin of the Mauchline basin. No coal-seams have been proven here, but a limestone, probably corresponding with the Hurlet or Hawthorn limestone, has been worked at Craigie, about 3 miles west of the Glasgow and South-Western Railway. There is very little prospect of any coal being found here, the strata being of the usual type north of the fault referred to above.

PATNA AND DALMELLINGTON.—On the western side of the basin a strip of Limestone measures comes to the surface, along the margin of the Dalmellington coal-field, from Dalmellington to Patna. The section as found at Patna is as follows:—

	Fms.	Ft.	Ins.
Black-band Ironstone, ...			
Millstone Grit Series, ...	160	0	0
Limestone, ...	2	3	0
Strata.	10	1	0
Limestone, ...	2	2	0
Strata, ...	10	0	0
Patna Coal,...	2	3	0
Strata, ...	23	0	0
Coal	0	2	6
Strata	9	5	0
Lower Limestone	2	0	0

At Gellieston the Patna coal is divided into three seams, which, however, are excavated in one working by a system of longwall.[1]

The section is as follows:—

	Ft.	Ins.	Ft.	Ins.
Fireclay, ...	3	0		
Top Coal, ...			6	0
Sandstone Plies, ...	4	3		
Mid Coal, ...			5	0
Dark Fakes, ...	3	5		
Bottom Coal, ...			4	6
Sandstone, ...	4	9		
			15	6

The Patna field is very much cut up with faults, whin dykes, and floats, and there are also a number of volcanic necks.

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[1] *Trans. Mining Inst. Scot.*, vol. xiv.

The general dip of the strata is about 1 in 6 to the north-west, but locally the dip is very irregular.

A bore-hole, fully 200 fathoms in depth, between Waterside and Dalmellington passed through the Limestone measures and found the coal-seams of that series burnt and useless; and several bores have been put down in the vicinity of Waterside with the same result. In the Patna district, where the Limestone measures crop out, and where the Patna thick coal is worked, 30 per cent of the coal-field must be deducted for whin dykes and burnt coal.[1]

The seams at Patna are dipping towards the west underneath the Coal-measures, and there is a reasonable prospect that they will be found workable in that direction.

There is a small area to the south-west of Dalmellington containing the Carboniferous Limestone series. The strata are very much disturbed, and have been invaded by several sheets of dolerite. What appears to be the Patna coal has been worked along the outcrop by the farmers and shepherds, but it is of very inferior quality, and contains several bands of dirt.

The Limestone measures are cut off by the large fault mentioned on p. 11, at a point about 1 mile north of Patna. North of this fault the Limestone series has been very poorly developed, and the coals are absent. A seam of Limestone has been worked near the Craigs of Kyle, about 1 mile north of the fault, but westward and towards Ayr the Upper measures appear to rest directly on the lowest rocks of the Limestone series, and there is no prospect of any of the Limestone coals being found here.

NORTH AYRSHIRE DISTRICT.—The Carboniferous Limestone series is found surrounding the northern edge of the coal-field in a continuous stretch from Ardrossan to Newmilns, and it is succeeded again by the interbedded igneous rocks of the Calciferous Sandstone period at Fenwick, Stewarton, and Beith.

The volcanic activity of Calciferous Sandstone age, denoted by the lava-formed plateaux of the Renfrewshire hills, continued during at least the earlier portion of the Carboniferous Limestone period, and interbedded volcanic rocks are thus a distinguishing feature of the Limestone measures in North Ayrshire. In addition to these interbedded volcanic rocks there are also numerous intrusive dolerites or "whins" belonging to a later period of volcanic activity. Some explanation of the occurrence of these igneous rocks is necessary before the structure of the field can be understood.

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[1] *Trans. Fed. Inst. Mining Engineers*, vol. xviii, p. 395.

During the time when the Lower Limestone measures were being put down in this district, the sea or lake in which they were being deposited must have been studded with low volcanic islands, from which there were intermittent outbursts of ash and debris, with very little lava. While the ordinary series of strata was being deposited in the open sea round those islands the volcanic ash was filling up the ground in their immediate vicinity, and spreading out round them in layers which became thinner and finer as they receded from the centre. The workings of the Dalry black-band ironstone have shown very clearly the result of this action. As the workings approach any of those volcanic cones the ironstone becomes more and more mixed with ash until it becomes unworkable. On the site of the volcanic cones the ironstone of course never existed, and in the vicinity of the cones it was continually being destroyed by the admixture of the ashes. In the Dalry district it would appear that the emissions from these volcanoes ceased shortly after the period when the ironstone was deposited, and the cones were gradually covered up by sandstones, shales, and limestones. It thus happens that the Upper Limestones are lying quite regularly over the top of these ancient volcanoes, and there is no indication at the surface to show what has taken place underneath. Farther south the emissions of volcanic ash continued until a later period, and in many places only trap tuff is found occupying the place of all the coal-seams and strata beneath the Upper Limestone. It will be readily understood from this circumstance that the coal and ironstone throughout the locality is very uncertain in its occurrence. The regular appearance of the Upper Limestone and other beds at the surface creates the natural impression that the coal-seams will be found with like regularity underneath. This deceptive appearance has led to much disappointment in boring operations. A case like this should make us more cautious in speculating on the probabilities of finding coals in the Limestone measures throughout other districts where these measures are covered by Millstone Grit or the Coal-measures. It is highly probable that in early Carboniferous times there were similar areas of volcanic activity, especially throughout the western districts, and that where we might expect to find coals there will be nothing found but volcanic ashes.

Other phases of volcanic activity are also seen in this part of North Ayrshire.

There is a great sheet of intrusive basalt occupying a position a little above the Upper Limestone, and forming the division line between the Limestone measures and the Coal-measures. This intrusive basalt is of course of a much later period than the volcanic tuff. In several places it is seen cutting through both the tuff and the adjoining strata. It does not affect the underlying coal-seams, as it is separated from them by about 50 to 60 fathoms of strata.

A still later period of volcanic activity is found, in the district we are describing, in the form of volcanic necks. A very interesting proof of the geological age of those necks is exhibited by one which is seen at Rowallan Castle, about 2 miles north-west of Kilmaurs. At that point the neck is found to have burst its way through the Carboniferous strata and the interbedded tuff, and also through the intrusive basalt. It must therefore belong to a later geological age than any of those rocks.

G

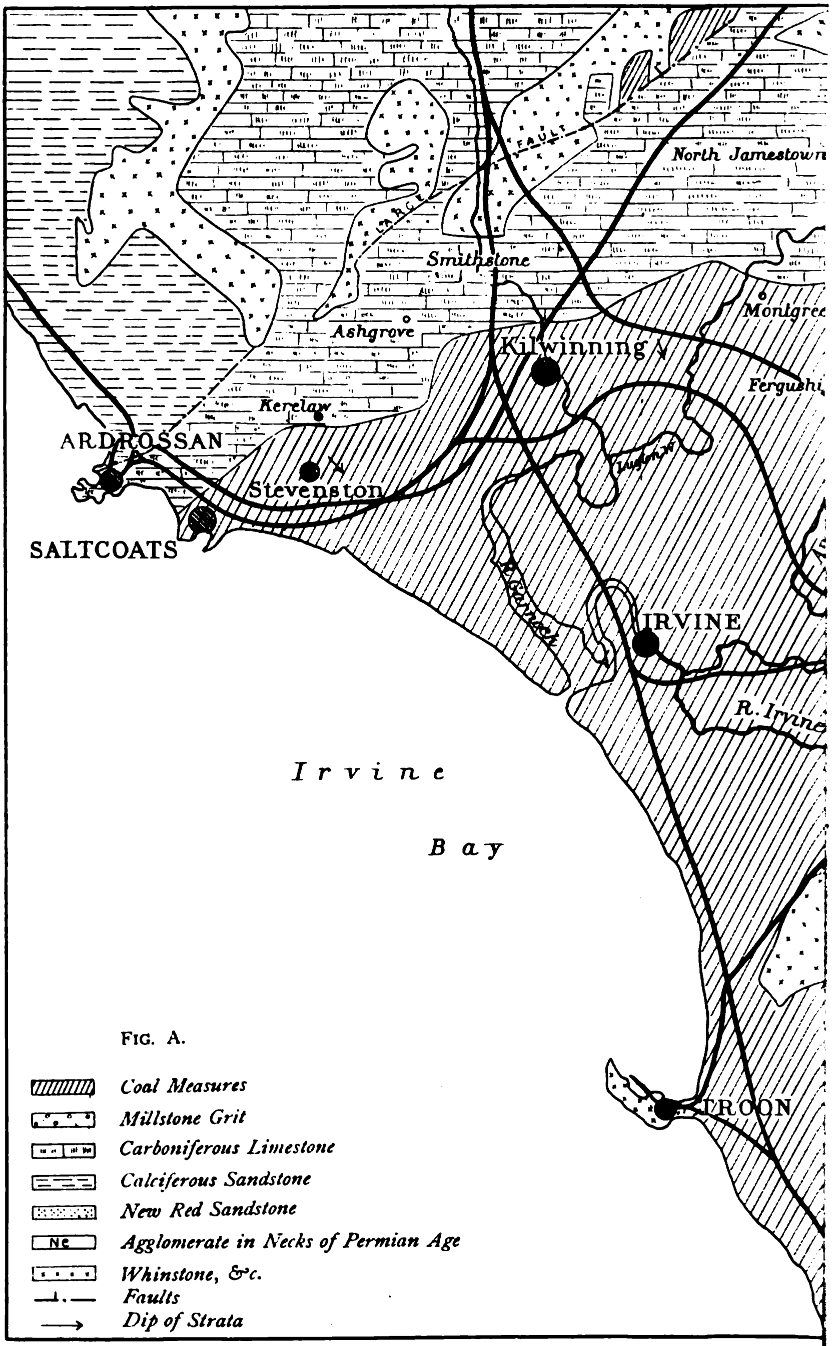
North Jamestown
LARGE
FAULT
Smithstone
Montgre
Ashgrove
Kilwinning
Fergushi
Kerelaw
ARDROSSAN
Stevenston
SALTCOATS
Lugton W.
R. Garnock
IRVINE
R. Irvine
Irvine Bay
TROON
Coal Measures
Millstone Grit
Carboniferous Limestone
Calciferous Sandstone
New Red Sandstone
Ne
Agglomerate in Necks of Permian Age
Whinstone, &c.
Faults
Dip of Strata

FIG. A.

Another of those necks is found at Alton, about 1½ miles north of Galston, and there are several in the district north of Stevenston.

An interesting feature in connection with the volcanic tuff is illustrated in a paper communicated to the Geological Society of Glasgow by Mr. John Smith[1]. Mr. Smith points out that at Montgrennan the lowest seam of the Coal-measures is resting directly on one of the tuff beds without the interposition of any fireclay. The vegetation from which the seam has been formed must have grown on the pure volcanic tuff. Stigmarian rootlets are abundant in the top part of the tuff next the coal. In connection with this tuff deposit Mr. Smith draws attention to a remarkable bed of ironstone, 4 feet thick, which he considers was formed by showers of fine irony dust, mixed with tuff dust, from some neighbouring volcano. This material has settled down in a quiet lake, thus forming the bed of ironstone. An analysis of the ironstone shows that it is a carbonate containing 26 to 28 per cent of iron in the raw state, and 41 per cent of iron after calcination. Regarding the extent of this bed, Mr. Smith remarks: "This ironstone has every appearance of extending in a bed unbroken, except by faults and dykes, from the shore at Saltcoats, where it is seen under tide mark, to Lugton water, a distance of 7 miles".

The normal section of the seams at Dalry is as follows:—

	Fms.	Ft.	Ins.
Upper Limestone	6	0	0
Coal	0 to 0	0	10
Strata	10	0	0
Limestone	5	0	0
Strata	10	0	0
Limestone	1	0	0
Strata	20	0	0
Highfield Limestone	1	0	0
Strata	4	0	0
Wee Coal (sometimes a gas coal) ...	0	2	3
Strata	3	0	0

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[1] *Trans.*, vol. x, p. 134

	Fms.	Ft.	Ins.
Smithy Coal	0	2	1
Strata	10	0	0
Borestone Coal	0	2	3
Strata	30	0	0
Black-band Ironstone	0	1	3
Strata	32	0	0
Clay-band Ironstone	0	1	1
Strata	1	0	0
Lower Limestone in beds	10 fms. to 15	0	0

The Dalry black-band ironstone has been very extensively worked, and is now practically exhausted. Some workings are still being carried on in the Clay-band Seam, and this ironstone is carried to the furnaces at Lugar to mix with the black-bands of that district. The clay-band ironstone is more fusible than the black-band. The mixture produces a quality of iron which is especially suited for fine castings, as it runs more evenly in the moulds.

During the recent boom several small collieries were opened up in the vicinity of Dalry and Barmill, but the coal was not very good in quality.

The Wee Coal was found as a gas coal at Kilbirnie, and was worked out many years ago. A gas coal about 12 inches thick has also been found in the vicinity of Barmill. Both the coal and ironstone have been worked underneath Kilbirnie Loch.

Towards the south the ironstones have disappeared, and at Kilmaurs the following section is found:—

	Fms.	Ft.	Ins.
Upper Limestone (in four posts)			
Coal	0	0	6
Strata	27	3	0
Coal (Wee Coal)	0	1	10
Strata	3	0	0
Coal (Smithy Coal)	0	2	4
Strata	2	0	0
Coal (Borestone Coal)	0	1	0
Strata	27	0	0
Lower Limestone in bands about 1 foot thick.			

At Craufurdland, about 3½ miles east from Kilmaurs, the section is again different.

SECTION OF BORE AT CRAUFURDLAND

	Fms.	Ft.	Ins.
Limestone			
Strata	10	0	0
Limestone (in four posts) ...			
Strata	9	0	0
Coal (foul)	0	0	11
Strata	2	0	0
Coal	0	2	7
Strata	2	0	0
Coal	0	1	6
Strata	2	0	0
Limestone	1	2	0
Strata	6	2	0
Coal	0	3	1
Strata	6	3	0
Coal	0	1	6
Strata	45	0	0
Limestone	0	2	0

The three coal-seams between the second and the third limestones may represent the Wee Coal, the Smithy Coal, and the Borestone Coal of Dalry.

The Limestone measures have also been tested by a bore at Caprington Colliery, about 3 miles to the south-west of Kilmaurs. The bore passed through the Upper measures, and the Limestone measures were found at a depth of 140 fathoms. The section below that depth was as follows:—

SECTION OF BORE AT CAPRINGTON

	Fms.	Ft.	Ins.
Limestone in beds			
Strata	30	0	0
Coal	0	0	6
Strata	1	3	5
Coal (with 3-inch parting) ...	0	2	4
Sandstone	0	4	3
Coal	0	0	9
Sandstone	1	3	6
Coal	0	2	6
Strata	1	2	9

	Fms.	Ft.	Ins
Coal	0	0	8
Strata	1	0	9
Coal	0	0	7
Strata	33	0	0
Coal	0	1	0
Strata	22	0	0

The total depth of the bore-holes was thus about 223 fathoms.

The fact that the three sections last quoted, although covering a space of only 6 miles, exhibit such great differences in the coal-seams would indicate that the conditions of deposition must have been very erratic. Viewing this circumstance in connection with the poor development of the Carboniferous Limestone series on the other edges of the basin, between Patna and Ayr and in the district north of Mauchline, it appears evident that the Limestone coal-seams are not likely to be workable to any considerable extent beneath the Coal-measures of North Ayrshire. Some thin seams probably exist in the area lying to the north of a line between Irvine and Kilmarnock, and these will be found at a depth of from 150 to 250 fathoms. When the upper seams are exhausted some of the pits will doubtless be deepened to prove those lower seams.

In the district north of Stevenston coals were worked from the Limestone measures many years ago, but there have been no recent workings in that locality. At Smithston, about 1½ miles north of Kilwinning, a pit was working about 1850. The shaft was sunk through limestone to coal 3 feet 6 inches thick at a depth of 12 fathoms. The coal was of a coarse quality, and was principally used for lime-burning. The area worked was very limited, as it was bounded on both east and west by large faults. It is said that the colliery was abandoned on account of a crush caused by an attempt to introduce the longwall system of working. Coal must have been worked here at a very early period, because the workings of 1850 broke through on to old waste, of which there was even then no tradition.

It is said that coals were worked 100 years ago on Kerslaw estate, half a mile north of Stevenston, but I can obtain no record of the nature of the seams or the extent of the working.

A 2-foot seam of coal was also worked thirty or forty years ago at *North Jameston*, a point on the Caledonian Railway 2 miles north from Kilwinning, and this coal has recently been reopened on a small scale.

There is an exposure of the Carboniferous Limestone measures in the area north of the Hurlford and Galston coal-field, between the latter town and Fenwick, in which the coals are practically unproven.

At Houletburn, about a mile north of Galston, a limestone, identified by the Geological Survey as the Upper Limestone, was worked many years ago. I am informed that a seam of coal about 3 feet thick was known to exist below this limestone, but it was never worked. When the limestone was being worked the coal required to burn it was brought from the adjoining coal-field in the carts which took away the lime, and this would lead one to suppose that the coal said to underlie the limestone cannot have been of much value.

Limestone was also worked on the farm of Berryhill, 2 miles north of Houletburn. The lime-works, which were abandoned twenty years ago, lie close to the Glasgow Road, about 3 miles from Galston. The limestone is dipping gently to the west. It was worked by the proprietor for agricultural purposes, and was burned with "blind coal" from Caprington Colliery. The seam was said to be 7 feet thick. Overlying the old workings a seam of very impure coal can be seen cropping out. The seam is about 2 feet thick, but part of it is so dirty that it might be described rather as coaly blaes than as coal. No coal was known to exist below the limestone, but there is no evidence of any attempt having been made to find coal-seams there. The whole of this district is isolated from any railway connection, and there is therefore in the meantime little inducement for anyone to carry out prospecting operations, but present appearances are not favourable to the supposition that any very valuable seams will be found here or in the corresponding series underlying the Galston coal-field.

In the area between Berryhill and Craufurdland an extension of the coals found in the Craufurdland bore, given on page 47, may possibly be found, and one or two hundred acres containing thin coal-seams may be also found at Houletburn.

In the Memoir of the Geological Survey it is stated in the description of this district that "The black-band and coal-seams of the Dalry district have frequently been searched for, but they have nowhere been met with in a workable condition. Some of the coal-seams have indeed been attempted, but so long as thicker seams are to be obtained in the adjacent coal-field of Kilmarnock it is not likely that these will be worked to a profit." This was written thirty years ago, and since then the only working of which I have been able to find any trace is that for limestone at Berryhill above referred to.

THE GIRVAN COAL-FIELD consists of an isolated strip of Limestone measures, stretching for about 4 miles along the Girvan valley. The coal-seams occupy a trough or synclinal fold, varying in width from a quarter to three-quarters of a mile, and they dip towards the centre at a very high angle. Lying in the centre of the trough there is a narrow strip of sandstone rocks which may represent either the Millstone Grit or the lower beds of the Coal-measures. The field is divided into three portions by two faults running at right angles to the line of level course. The first of these faults is about 1½ miles north of Dailly station, and the other is about 1 mile south of that station. The principal coal-workings have been in the central division of the field, between those two faults—at Kilgrammie and Dalquharran. The workings are drained by an adit level driven across the strata from the Girvan Water. The section of the strata, compiled partly from bores and partly from measurements in the shafts and crosscut mines, is as follows:—

	Fms.	Ft.	Ins.
Strata (mostly very hard sandstone with bands of "Kingle")	60	0	0
Limestone	3	2	0
Dark Blaes	0	1	10
Coal (foul and splinty)	0	1	3
Strata (mostly hard sandstone)	10	0	0
Limestone (hard and impure)	0	4	0
Strata (mostly blaes)	5	0	0
Dalquharran Limestone	0	4	0
Strata (mostly hard limey sandstones)	17	0	0
Wild Coal	0	2	0
Shale	0	2	6
Blaes	0	1	6
Main Coal	1	1	0
Fireclay	0	2	0
Ground Coal	0	2	6
Strata	0	4	6
Little Coal or Ell Coal	0	4	0
Strata	2	0	0
Parrot Coal or Sulphury Coal	1	0	0
Strata	1	4	0
Coral Coal	0 to 0	5	6
Strata	3	0	0
Craigie Coal	1	2	6
Strata	5	0	0
Rotten Coal	1	0	0
Strata	10	0	0
Captain's Bridge Limestone	4	0	0

The seven seams from the Main Coal to the Rotten Coal contain about 40 feet of coal, most of which is workable. The general quality of the coals can only be described as *fair*; most of them are very coarse, and contain a high percentage of ash. They are, however, very useful for local purposes, and are convenient for shipment at the adjoining harbour at Girvan, and have been worked more or less during the last 100 years.

The following analysis of a portion of the Craigie Coal Seam gives a fair idea of the quality:—

ANALYSIS OF KILGRAMMIE SPLINT COAL MADE BY GEORGE R. HISLOP, F.C.S., &c., PAISLEY

Mineralogical Characters

The coal is black and of moderate lustre, and brown streak; fracture inclining to slaty and undulating; cross fracture angular and coarse, with deposits of clay, ferric bisulphide and trace of calcium carbonate in the natural partings; moderately cohesive and compact; on the fire it slightly and partially intumesces; colour of ash, pinkish white; thickness of seam, 24 inches; mean specific gravity, 1324 (water, 1000); weight of one cubic foot, 82.75 pounds.

Chemical Analysis

Volatile Matters (containing .32 of Sulphur	...	33.37 per cent.
Coke, consisting of	Carbon ... 52.29 Sulphur ... .34 Ash ... 8.15	... 60.78 ,,
Water expelled at 212 degrees Fahr. ...	...	5.85 ,,
		100.00

Practical Results

Gaseous Products

Gas per ton of Coal at 60° Fahr. and 30 in. Bar. ...	10,520 cubic feet.
Value of Gas from One Ton of Coal in Sperm ...	779.80 pounds.
Illuminating power of Gas in Standard Candles (per London Argand)	21.62 candles.

Liquid Products

Tar per Ton of Coal	14.52 gallons.
Ammoniacal Liquor per Ton of Coal	22.20 ,,
Strength of Ammoniacal Liquor	2.15 degrees Twadd.

Solid Products

Coke per Ton of Coal	1361.47 pounds.
Carbon in the Coke	86.60 per cent.
Ash in the Coke	13.40 ,,
Sulphur in Coke per Ton of Coal	7.61 pounds.
Heating Power of One Pound of Coke (*Water from boiling point into Steam*)	11.89 ,,

Remarks.—This coal yields a good volume of 21.62 candle gas, and affords 12.15 cwts. of coke per ton, which, however, is of but medium quality. The coal is easily distilled, and the foul gas contains about the average amount of impurities. Compared with Main Lesmahagow Cannel Coal, represented by 100 (calculated on the basis of a production of 13,000 cubic feet of gas and 1535.5 lbs. of sperm per ton, and having regard also to the value of the secondary products and the cost of the purification of the gas) this coal is equal to 51.74.

The Main and the Ell Coal Seams are the best seams, and are nearly exhausted in the central portion of the coal-field. The Rotten Coal is being worked to a small extent, and the Craigie Coal has also been tried, for gas-making purposes.

At the south-western end of the coal-field there is an area which has not yet been developed. The depth to the Main Coal in the centre of that area is over 100 fathoms, and the overlying rocks are extremely hard and will be expensive to sink through.

The fireclays associated with the Main Coal make excellent fireclay goods, and have long been used for that purpose.

A coal-seam at Kilkerran has been on fire for over two centuries. Mr. Bald of Edinburgh, in a communication to the Wernerian Society in the year 1828, gives the following notes regarding the burning:—"A fire at Kilkerran is reported to have existed for more than a century, the spot retaining the name of the burning hill to this day.

"The seam below that which was on fire was extensively worked, and was greatly influenced by the heat, inasmuch as the drops of water which fell from the roof were scalding hot, and the candles were melted by the heat of the mine. In some places at the surface the argillaceous schistus had been melted into glass or slag.

"The subterranean heat had such an effect upon the surface that the proprietor converted part of the ground into a nursery for the rearing of forest trees, which grew vigorously; but when they were removed to less genial climes the suddenness of the change killed the plants."

The fire at Kilkerran is supposed to be exhausted, but there is another coal seam on fire at Dalquharran. The burning is separated from the present workings by a whin gaw.

II. Upper Coal-Measures

NEW CUMNOCK.—The minerals of the New Cumnock district were first developed on an extensive scale by the establishment of the Bank Ironworks in the year 1845. These ironworks were situated at Bank, about 2 miles from the present village of New Cumnock, at a point convenient for obtaining a supply of suitable coal. The ironstone worked was the famous Dalmellington Blackband Ironstone, a form of ironstone which was in very great request in the earlier years of the Scottish iron industry. The ironstone-workings were situated at Beoch, a point about 6 miles from New Cumnock, and 3 miles from Dalmellington. The ironstone was conveyed from the mines to the furnaces by a light railway nearly 4 miles in length, of which the bridges and some of the formation still remain.

The ironworks continued in operation until about the year 1855, when they were abandoned on account of the difficulty of finding a splint coal of the quality required for smelting.

It was about the same time that the cannel coal, which has made the field so valuable, was first discovered, and since that date the district has experienced a steady and progressive prosperity, and it can now boast of some of the deepest and finest equipped pits in the country.

With the exception of a small area at Pathhead the Upper Coal-measures of this field are situated entirely to the west of the Glasgow and South-Western main line, with which the pits are connected by branch railways several miles in length. Most of these branch railways are now the property of the Glasgow and South-Western Railway Company.

On the south the Coal-measures crop out and are succeeded by the Carboniferous Limestone series, except at Dalleagles, where they stretch right to the great boundary fault, and are there thrown in contact with the Old Red Sandstones. They continue for some distance down the valley of the Nith along the line of the Glasgow and South-Western Railway, and probably at one time were coterminous with the Sanquhar Coal-measures. Between the New Cumnock and Sanquhar fields there is now a space of about 2 miles from which the Coal-measures have been entirely denuded, exposing the underlying Old Red Sandstones. On the north-east the coal-field is cut off by a large fault which throws up the Limestone measures, or the Millstone Grit, into contact with the Coal-measures. The northern boundary is formed by an area of moorland, lying at a level of about 1200 feet above the sea, which separates the New Cumnock from the Old Cumnock coal-field. This area has not yet been prospected, as it lies far away from any existing railway. On the west the New Cumnock coal-field merges into that of Dalmellington.

Although the area thus described extends to about 16 square miles, practically all the coal-workings have been confined during the last thirty or forty years to an area of about 2 square miles, situated near the village of New Cumnock, and the stores of coal in the remaining 14 square miles, amounting probably to over 100,000,000 tons, have not yet been exploited. The area in which the present workings are being carried on is separated from the remainder of the coal-field to the west and north by a series of large faults having an upthrow to the north of between 100 and 200 fathoms. Although the underground workings are very extensive they have not yet proven the exact lie of those faults, and the geological structure of the field is as yet somewhat uncertain.

On the map, Plate III, the position of a volcanic neck is shown about 3 miles west of New Cumnock. It seems probable that this neck is the vent of a volcano that burst up through strata which had been already fractured and weakened by the faulting, and it may thus be taken as the division line between the two portions of the coal-field. The volcanic neck is represented at the surface by a hill about 1 mile long by ½ mile wide, composed of very characteristic volcanic tuff and breccia. The hill, being composed of harder materials than the surrounding shales and sandstones, has resisted denudation so much better that it now forms an eminence rising several hundred feet above the adjacent country. The underground workings have not yet approached the edge of the volcanic neck. The principal faults found in the workings appear to run nearly parallel with the great Silurian boundary-fault, and they generally increase in size and frequency towards the dip of the field. The main fault, known as "Prentice's fault", commences at nothing and gradually increases in size to at least 30 fathoms, with a downthrow towards the north-east. The faults are seldom clearly defined, being generally composed of small steps and troubles spreading over a considerable area.

Overlying the coal-seams there is a bed of intrusive whin varying in thickness from 12 feet to 40 feet, and usually maintaining a uniform position about 36 feet above the Upper Gas Coal, as shown in the section, p. 58. The regularity with which this whinstone has spread itself over such a large area is very remarkable. It can be seen outcropping on the public road near Bank Glen, and it was found in the Rigfoot pit, about 1¼ miles distant, at a depth of 169 fathoms. In the intervening area its position has frequently been proven by bores and shafts, and it has also been encountered when cutting faults in the underground workings. The whin seems to have been injected before the main faulting of the strata had taken place, as it generally maintains about the same relative position above the Upper Gas Coal. I am inclined to think that the point of origin of this whin is towards the south, as it appears to be getting thinner going from south to north. Towards the southern outcrops the coal-seams have been burnt in places, but no effect of this kind can be detected to the north. In the south-eastern portion of the field another floating whin is found occupying a position between the Upper and Lower Gas Coals. That whin can be seen very prominently at the side of the road between Connel Park and Bank Glen. It also must have had its origin towards the south, as it dies out altogether before reaching Lanemark pit, about half a mile north of the above-mentioned exposure.

A number of whin "gaws" or dykes are also found in this field, generally running east and west. They seldom exceed a few feet in thickness, and in most cases cut clean through the coal-seams, only burning them for a few feet on either side. In one or two instances, however, sheets of whin have been injected from those dykes through the coal, and thus causing considerable damage. An interesting section is exposed in the underground workings, showing that a whin gaw was injected prior to the tilting of the strata.

The coal is burnt at 2, 2 for a distance of 12 inches on either side of the whin. At 3 the coal is not injured in any way. When the strata was being tilted the beds seem to have slid on one another just as leaves of a book do when bent round. By this action the whin has been broken, and now shows a lateral displacement of about 4 feet. This little section thus gives us a clue to the relative periods of the intrusion of the whin and the displacement of the strata, which latter was probably coincident with the faulting. It also proves that there has been a lateral movement among the beds of the strata.

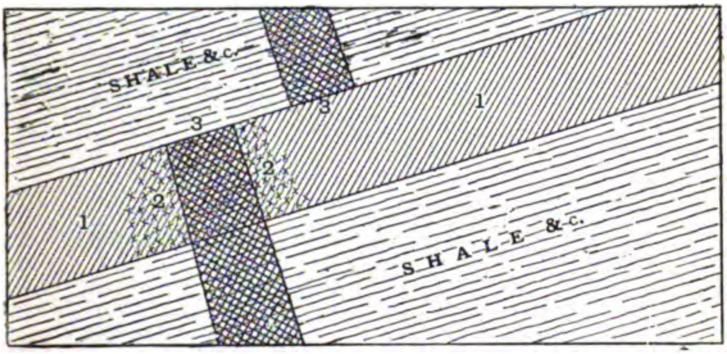

Fig. 2.—Diagram showing Displacement of an intrusive Whin Dyke proving lateral movement of Strata after the interjection of the Whinstone

1, Coal seam. 2, Burnt coal on edge of whin. 3, Whin dyke.

In the area at present being worked the average dip of the strata is about 1 in 5, although it varies greatly.

Towards the south-eastern outcrops it is almost flat, but towards the west it becomes as steep as 1 in 1½. The line of dip varies from due west to nearly due north, so that the coal-field takes the form of a segment of a basin.

An average section of this district, ***taken at right angles to the dip of the strata***, is as follows:—

SECTION AT NEW CUMNOCK

		Fms.	Ft.	Ins.
Upper Red Sandstones, about		86	0	0
Coal		0	2	2
Strata		7	5	8
Coal		0	2	11
Strata		4	5	5
Coal		0	2	7
Strata		8	1	6
Coal		0	1	11
Strata		6	1	10
Coal		0	1	11
Strata		19	1	5
Coal	Coal 1 ft. 4 ins. Fireclay 2 ft. 0 ins. Coal 2 ft. 0 ins.	0	5	4
Strata		5	1	6
Coal		0	2	4
Strata		12	4	3
Coal		0	1	2
Strata		6	2	9
Whinstone		1	4	0
Strata		6	3	11
Upper Gas Coal		1	0	0
Strata		7	3	10
Coal		0	1	2
Strata		10	2	0
Lower Gas Coal		0	5	6
Strata		8	3	9
Eight-foot Coal	Coal 2 ft. 1 in. Fireclay 1 ft. 5 ins. Coal 5 ft. 0 in.	1	2	6
Strata		17	0	0
Three-foot or Coking Coal		0	3	5
Strata		3	0	0
Four-foot Coal		0	4	0
Strata		10	0	0
Coal		0	3	0
Strata		4	0	0
Mussel-band Ironstone Coal		position		
Strata with the position of the Coalburn and Craigman Coals		47	0	0
Black-band Ironstone		0	1	0

The Upper and Lower Gas Coal Seams have been very extensively wrought on account of the cannel coal which is associated with them. The following are average sections of those seams:—

UPPER GAS COAL

	Ft.	Ins.
Gas Coal, Heads	1	0
Gas Coal, Breasts	3	1
Common Coal	2	0

LOWER GAS COAL

	Ft.	Ins.
Gas Coal	1	0
Common Coal	5	0

The gas coal is lustrous black in colour, with a brown streak. It is hard and splintery, with a somewhat slatey fracture, sometimes conchoidal. On the fire it decrepitates and splits in various directions. Taking Lesmahagow gas coal at 100, the comparative value of this gas coal is from 72 to 84.

The following is an analysis of the New Cumnock cannel coal, by Mr. Alex. Bell of Peebles Gas-works, made in 1892:—

CHEMICAL ANALYSIS

Volatile Matter (containing .30 of Sulphur)			36.67 per cent.
Coke	Carbon ...	51.67	58.33 ,,
	Sulphur ...	.36	
	Ash	6.30	
Water expelled at 212° Fahr.			5.00 ,,
			100.00

ANALYSIS OF COKE

Carbon	88.58 per cent.
Sulphur	.62 ,,
Ash	10.80 ,,
	100.00

PRACTICAL RESULTS

Gas from 1 ton of coal at 60° Fahr. and 30 inch Bar.	10,833 cubic feet.
Durability of 1 cubic foot of gas by 5-inch jet flame	57 min. 24 sec.
Illuminating power of gas in standard candles ...	28.40 candles.
Value of gas from 1 ton of coal in sperm	1054.82 pounds.
Value of 1 cubic foot of gas in sperm	681.60 grains.
Sulphur eliminated with volatile products	6.72 pounds.
Coke (dry) per ton of coal	1306.66 ,,
Sulphur in coke per ton of coal	8.06 ,,
Tar and ammoniacal liquor per ton of coal	33.32 gallons.

REMARKS.—As a second-class cannel coal this is one of the best that I have had occasion to test. It is of a lustrous black colour, and gives a dark-brown streak. The average specific gravity is 1270 (water being 1000).

When worked on a practical scale, it yields over 10,800 cubic feet of gas of 28½ candle power, and fully 11½ cwts. of good coke. It contains a very moderate amount of sulphur, and about the average percentage of water.

In obtaining the above results, 2 tons of the coal were distilled—without an exhauster—in six clay retorts, and the gas was collected for examination in a separate holder.

There is another Cannel Seam between the Upper and Lower Gas Coals, which at places has been found 24 inches thick. It has not yet been worked, mainly because it is very hard, with a rock roof and pavement, and is thus more expensive to get than the other seams at present available. As the quality is fairly good it may be looked upon as a future reserve.

The common coal of the Lower Gas Coal Seam is a soft, black coal of very high quality for household purposes.

The seams underlying the gas coals are now being worked mainly for manufacturing, steam, and locomotive purposes. The Three-foot Coal makes an excellent coke, although not at present used for this purpose. The Four-foot and Eight-foot Seams are mixed with bands of dirt and with "brasses", and therefore require to be carefully screened and picked to prepare them for the market. The under seams are not so regularly developed throughout the field as the two upper seams. They appear to thin out and become unworkable as they approach the great Silurian fault, as if they also had been, to some extent, affected by the same adverse conditions as were mentioned when describing the Carboniferous Limestone coals of this district (p. 37).

As before mentioned, the area in which the present workings are being carried on is bounded on the north-west by a great fault which throws up the Millstone Grit and limestones at Benston. On the rise side of this fault a small area of the Coal-measures is found, apparently lying conformable with the Lower measures. Several bores have been put down in this area in the vicinity of

Creoch Loch, showing important seams of coal. There are some old shafts here which were abandoned more than thirty years ago, but there is no record showing what seams were worked. The seams found in the bores appear to correspond with those found in the position between the Mussel-band and Black-band Ironstone in the district next described. Some of them are over 6 feet thick. As no shafts have been sunk in recent times, nothing can be said definitely as to the position or quality of those seams beyond the fact that there is here undoubtedly a great quantity of coal awaiting development. Some deep bores were put down, in 1901, a little to the south of the village of New Cumnock. I am not in a position to give the results of those bores, but it may be stated that a coal supposed to be the "Eight-foot Coal" was found as an excellent splint coal, and there is a probability of pits being sunk to work it.

The same series of coals has also been worked at Pathhead, to the north of the Glasgow and South-Western Railway. At Pathhead Colliery an oil-shale was worked, which may possibly represent the position of one of the Lanemark Gas Coals, although there is no evidence to establish an exact correlation.

The section of the other coals worked at Pathhead seems to show a transition between the seams of the Lanemark and Sanquhar basins.

The Black-band Ironstone is found at Pathhead as an impure pyritous gas coal or shale, which was formerly used for making alum.

The remaining portion of the New Cumnock coal-field lies on the north-west or rise side of the fault which, for want of a better name, may be described as the Whitehill fault.[1] A large number of bores have been put down in this area, and there are also a number of shallow pits and mines from which the coal was worked over fifty years ago. The seams which have thus been proven occupy a position between the Mussel-band and Slatey-band ironstones, and thus correspond with the Camlarg and Coking Coals of the Dalmellington coal-field. These I take to correspond with the Drumgray and Armadale coals of the Lanarkshire section.

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[1] P. 55.

The seams here are dipping towards the south at a very moderate inclination — in fact they are at places lying quite flat. The only working pit in the district is at Coalburn, on the Marquis of Bute's property. The seam worked is known as the Coalburn Splint Coal. It is about 3 feet thick, and is of very high quality as a steam coal. The workings are only on a small scale, as there is no railway connection, and the output has all to be carted either to Old or New Cumnock.

A great many shallow bores have been put down along the valley of the Nith to the south and south-west of the Coalburn pit. The two following sections, found respectively at Dalgig and Craigman, may be taken as fairly representative of the seams as found in those bores:—

SECTION AT DALGIG

	Ft.	In.	Fms.	Ft.	Ins.
Strata			8	0	0
Coal			0	1	10
Strata			3	4	0
Coal			0	0	10
Strata			10	0	0
Coal			0	2	3
Strata			1	0	0
Coal	0	10	0	5	6
Blaes	2	0			
Coal	2	8			
Strata			1	0	0
Coal			0	2	1
Strata			13	0	0
Coal			0	1	4
Strata			4	0	0
Black-band Ironstone			0	1	4

SECTION AT CRAIGMAN

	Fms.	Ft.	Ins.
Coal	0	2	4
Strata	1	2	0
Coal	0	1	8
Fireclay	0	0	8
Coal	0	1	8
Strata	1	2	6
Coal	0	3	6

At Craigman there is a sheet of intrusive whinstone overlying the coals. The coal at some places has been completely destroyed by this whin, but in the old Craigman pit the seam worked had been converted into a very fine smithy coal; for which purpose it was in great demand, even though the coals had to be carted 4 or 5 miles to the railway.

A peculiar effect of the whin on a coal-seam is found in the old workings of the "Waud Mine", near Craigman. The whin there lies directly above the coal, forming the roof of the workings, and these workings are still open. The "Waud" consisted of a band of coal which was in contact with the whin, and had been converted into graphite by the action of the heat. Judging from the extent of the workings this graphite must have been of considerable value, but tests made on a specimen which I obtained from the old workings showed it to be of inferior quality as compared with the foreign graphite now used. In a paper read before the Geological Society of Glasgow,[1] by Mr. John Smith, it was stated that a microscopic examination of this graphite revealed the presence of very minute *diamonds*. If nature had been a little more lavish, and made the diamonds on a somewhat larger scale, the New Cumnock district might have been a formidable rival to Kimberley!

A series of bores was put down recently on the farm of Lanehead, about 1 mile south of the Dalgig bore, just quoted. The indication from the bores is that the strata is dipping about 1 in 6 to the south. I cannot correlate the seams found in those bores either with the Dalgig bores or with the coals of the Lanemark section. By conjoining two of the bores the following section is obtained:—

SECTION AT LANEHEAD (NEW CUMNOCK).

	Fms.	Ft.	Ins.
Strata	12	0	0
Coal	0	2	0
Strata	0	5	0
Coal (Gas)	0	3	4
Strata	5	4	0
Coal	0	4	0
Strata	5	5	0
Coal	0	2	0

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[1] *Transactions*, vol. x, p. 257.

The bore was continued for 10 fathoms farther, but no seam, such as the Mussel-band or Black-band Ironstone, was met with which might be used as an index to show the stratigraphical position.

In adjacent bores a seam of limestone was obtained about 2 fathoms thick. Taking the ordinary dip and rise of the strata this limestone would appear to lie only 20 fathoms below the lowest coal in the foregoing section. There may, however, be a fault between the bores.

There is not yet sufficient data available on which to base a definite opinion regarding the structure of this field, and as it is a long distance from the railway there does not appear to be any near prospect of it being opened up by working pits.

To the north-west of Coalburn and Craigman there is an area of high ground extending to about 20 square miles, and stretching across to the Polquhairn and Drumsmudden coal-fields. About one-third of this area is covered by basalt rocks. Those basaltic intrusions appear to run more or less parallel with the planes of stratification, and form hills which rise to an elevation of 1000 to 1200 feet above the sea-level. The surface is thickly covered with peat, so that the outcrops of the strata are almost entirely obscured. The majority of the whinstone sheets appear to occupy a horizon above that of the Craigman and Coalburn Coals, and there is thus a reasonable probability that some of those seams may be found here in a workable condition underlying the intrusive rocks. Outcrops of a few thin coal-seams can be traced in some of the streams, but with this exception the district is quite unexplored. It is somewhat inaccessible from any of the surrounding railways. At the present rate of output it will be many a year before the available coal in the adjoining coal-fields approaches exhaustion. There is therefore, in the meantime, very little inducement to prospect this area, but in the future it may prove to be a valuable reserve. It is worthy of note that this is the only extensive area of Coal-measures in Scotland which has not been thoroughly prospected, and had the recent attempt to introduce a competitive railway into the district been successful it would doubtless ere now have been an important source of production.

It may be noticed in passing that some of the basalt of this district possesses in an eminent degree most of the qualities required for forming paving-setts and curbs.

Many years ago it was quarried for this purpose at Tappet Hill, near Craigman. In spite of the fact that the produce had to be carted several miles to the railway the workings were on quite an extensive scale.

A seam of ganister has been worked to a limited extent on the farm of Mansfield, near New Cumnock. An analysis of the ganister, made in 1888 by Dr. W. Wallace, gas-examiner for the city of Glasgow, gave the following results:—

The Original Rock contains—

Burnt material	96.94
Combined water and organic matter	2.90
Moisture at 212°	.16
	100.

The Burnt Ganister consists of—

Silica	90.75
Titanic Acid	trace
Alumina	7.14
Peroxide of Iron	1.46
Lime	.33
Magnesia	trace
Potash	.31
Soda	.16
	100.15

"This is an excellent description of ganister, well adapted for lining cupolas and other purposes to which this mineral is applied. It will also make silica bricks of the *finest quality*, but these will require to be raised to a very intense heat in firing in order to render them compact and hard."

This ganister was found near the base of the Coal-measures. The working was suspended principally because of the distance from the railway and the heavy cost of cartage, but no doubt it will again receive attention in the future.

DALMELLINGTON COAL-FIELD.—In the Dalmellington coal-field a series of coal-seams is found having a very close resemblance to the coal-seams of the Clyde basin. Above the coals there is a seam of ironstone, known as the Craigmark Black-band Ironstone, which appears to correspond with the Palace-craig Ironstone of Lanarkshire. Underlying this there is a series of coals corresponding generally with the seams from the Glasgow Upper Coal to the Virtuewell Coal. There is then a Mussel-band Ironstone, which may correspond with the Mussel-band Ironstones found between the Virtuewell and Kiltongue Coals. Following this there is a series of coals corresponding with the Kiltongue, Drumgray, and Armadale Coals, and at the base of the series is found the Burnfoot Black-band Ironstone, corresponding with the Slatey-band Ironstone of Lanarkshire. While this general relationship of the seams can be established, it is quite impossible to correlate the individual seams.

It is supposed locally that the coal above the Sillyhole Coal is the same as the Lanarkshire Ell Coal, but it is quite as probable that during the period the Ell Coal was being formed in Lanarkshire some of the shales and sandstones may have been in course of deposition at Dalmellington.

The seams cannot even be correlated, except in the above general way, with the adjacent coal-field of New Cumnock. The Geological Survey express the opinion that the Sillyhole Coal corresponds with the Upper Gas Coal of New Cumnock, and that the Chalmerstone Coal corresponds with the Lower Gas Coal. This may be correct; but it is evident that many of the seams of the Dalmellington district are not represented at all in the

New Cumnock section, so that any exact correlation is a mere speculation which can neither be proven nor disproven. A very good example of the alteration which may take place in a seam is shown in the Burnfoot Black-band Ironstone. From Dalmellington westward to Beoch this seam is found as a very valuable ironstone about 2 feet thick, but from Beoch to New Cumnock it is only represented by a seam of impure ironstone a few inches thick, while at Pathhead it is found, as above mentioned (p. 61), in the form of an impure pyritous gas coal.

The following is the general section at Dalmellington:—

	Fms.	Ft.	Ins.
Coal	0	0	10
Strata	16	0	0
Coal	0	1	6
Strata	18	0	0
Coal	0	3	6
Strata	1	3	0
Craigmark Black-band Ironstone	0	1	6
Strata	4	0	0
Coal	0	3	0
Strata	11	3	0
Coal	0	4	0
Strata	6	0	0
Coal	0	1	9
Strata	7	0	0
Coal	0	2	6
Strata	13	3	0
Sillyhole Coal	1	0	0
Strata	6	3	0
Coal	0	2	0
Strata	16	0	0
Diamond Coal	0	4	6
Strata	18	0	0
Chalmerstone Coal	0	5	0
Strata	12	0	0
Minnevey Coal	0	4	6
Strata	14	4	0
Sloanstone Coal	0	3	6
Strata	18	2	0
Coal	0	1	11
Strata	9	0	0
Coal	0	2	9
Strata	4	0	0

	Fms.	Ft.	Ins.
Mussel-band Ironstone	0	1	0
Strata	2	0	0
Camlarg Coal	0	4	4
Strata	4	3	0
Coal	0	3	0
Strata	18	0	0
Upper Coking Coal	0	2	6
Strata	7	3	0
Pennyvenie Splint Coal	0	3	8
Strata	9	1	0
Lower Coking Coal	0	3	11
Strata	11	0	0
Mussel-band Ironstone	0	0	4
Strata	3	0	0
Burnfoot Black-band Ironstone, corresponding with the Black-band Ironstone of Lugar and the Slatey-band Ironstone of Lanarkshire	0	2	3

The continuation of the Dalmellington section to the coals of the Carboniferous Limestone is given on page 41.

The above section shows nineteen seams of coal with an aggregate thickness of 61 feet 10 inches contained in about 1400 feet of strata.

The seams above the Sillyhole Coal are only found in a comparatively limited area, having been mostly removed by denudation. The Craigmark Black-band Ironstone crops out about half a mile west of Dalmellington village, dipping to the east underneath the village. There is only a very small area of the ironstone, however, as it is cut off on all sides by powerful faults. On the north side it is cut off by a large fault, which runs more or less parallel with the railway from Dalmellington to Patna. This fault has a throw of 50 to 60 fathoms up to north. The ironstone outcrop is again found on the hillside about 500 feet above the level of the railway, apparently dipping under the whinstone of Craigmark and Chalmerstone hills. The Craigmark Ironstone appears to correspond with the Palace-craig Ironstone of Lanarkshire. Mr. David Smith, who has had the practical management of the development of this field during the last fifty years, considers that the 2-foot-6-inch coal-seam above the Sillyhole Coal corresponds with the Lanarkshire Ell Coal, and the Four-foot Seam, 13 fathoms higher up, is the Upper Ell Coal. This latter seam has been passed through in some of the pits, but too near the surface to allow of its being worked. The two seams above and below the Craigmark Ironstone have also been worked to a limited extent, and found of good quality. The other seams on the section marked simply "coal", but without a name, have not yet been worked.

The Sillyhole Coal was a first-class furnace and house coal, but it is now practically exhausted. It is also known as the Main Coal.

The Diamond Coal has not been worked to any extent.

The Chalmerstone Coal, which is 5 feet thick, is a first-class house-coal, and is also used for the furnaces. It corresponds with the Ayr Hard Coal, and may be in the same horizon as the Lanarkshire Splint Coal. This seam has been destroyed by an intrusive whinstone throughout a considerable area north of Dalmellington.

The Minnevey Coal, which lies from 10 to 12 fathoms below the Chalmerstone, is a house coal of only second-class quality, but it has been extensively worked.

As has been noted in other districts,[1] the lower coals of the section have coking properties which are not found in the upper coals. The Sloanstone Coal, which may correspond with the Lanarkshire Virtuewell, is the first of the coking coals, and is also a good steam coal. The best coking coal in the section was the Lower Coking Coal of Pennyvenie, but this seam is now practically exhausted.

At Beoch, about 3 miles north-east of Dalmellington, the Pennyvenie Coals have been slightly burned by the action of intrusive whin, with the result that they have been converted into very valuable coals for smithy purposes. The Pennyvenie Lower Coal was first worked at Beoch by the Bank Iron Company, and conveyed by them to New Cumnock, but during the last thirty-six years it has been worked by the Dalmellington Iron Company in conjunction with their Dalmellington collieries. It is known in the market as the Auldnaw or Beoch smithy coal.

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[1] See p. 106.

The famous Dalmellington Black-band Ironstone has, during the last half-century, been the principal mineral of this district, although coal-workings have been in operation for at least 200 years.

The Dalmellington Iron Company first began boring operations about the end of 1845, and, having proved the ironstone, they erected the furnaces at Waterside in 1847, and since that date have carried on the operation of making pig-iron. The iron made from this black-band is of first-class quality, and is largely used for castings where soundness and reliability are required.

The ironstone occupies the same horizon as the Lugar Black-band and the Slatey-band of Lanarkshire.

Extensive boring operations have been conducted by the Dalmellington Iron Company in search of an extension of this seam beyond the Dalmellington area. As before mentioned, it has been found to change its character going towards New Cumnock, and has become an impure gas coal. It has also been bored by Corbiecraigs, Burnfoot, Bowhill, and Rankinstone to Polquhairn, but was found too thin to be workable.

An analysis of this ironstone gives 28.69 per cent of iron in the raw state, and 44.80 per cent after calcination.

The output of ironstone is not now sufficient to keep all the furnaces working, and imported ore is also used. The Mussel-band Ironstones shown on the section have not been worked, but the Craigmark Black-band Ironstone is now exhausted.

A very considerable proportion of the coal-seams of this district have been destroyed by intrusive whinstones. The whole area to the north-east of Patna has been so much affected in this way that the coals above the Black-band Ironstone have been rendered useless. Some compensation for this may be found in the fact that in the southern portion of the field, where the principal intrusive sheets occupy a higher stratigraphical horizon, they have been instrumental in protecting the coal-seams from denudation.

Cumnock and Lugar.—This district is bounded on the north by a great upthrow fault, which at Glenlogan throws the Limestone measures into contact with the Coal-measures. The extension of this fault to the west cannot be accurately traced, as it is overlain in the vicinity of Catrine and Sorn by the Upper Sandstones, and these in turn are overlain by the Permian rocks of Mauchline district. The newer beds do not appear to have been affected by the fault, but it seems very probable that it extends westwards for some distance, following the course of the river Ayr.

Towards the east the Coal-measures crop out on Aird's Moss, but are thrown down again by a fault which brings in the Wellwood basin, and towards the south and south-west they form a continuation of the Ayr, Dalmellington, and New Cumnock Coal-measures.

The coals of this district are much thinner than those of either Kilmarnock or New Cumnock. The seams principally developed correspond with the Upper series of Lanarkshire from the Ell Coal to the Virgin Coal. It is of course impossible to establish an exact correlation, but it is probable that either the Ell Coal or Main Coal of the Cumnock section represents the Ell Coal of Lanarkshire. There is also a series of lower seams, mostly of an inferior quality and thickness, corresponding either with the Drumgray Coals or with the Armadale Coals of the Scottish central coal-field. The Ell and Main Coals correspond with the M'Naught and Tourhall Coals of Kilmarnock, and the Maid or Splint Coal corresponds with the Hurlford Main.

General Section of the Cumnock and Lugar Coal-Field

		Fms.	Ft.	Ins.
Ell Coal (M'Naught)	4 ft. to	0	5	6
Strata		10	0	0
Main Coal (Tourhall)	4 ft. to	0	5	8
Strata, with two thin coal seams corresponding with the Major Coal of Kilmarnock	30 fms. to	45	0	0

	Fms.	Ft.	Ins.
Claud Coal (Stone)	0	2	3
Strata	7 fms. to 14	0	0
Maid or Splint Coal (Ayr Hard and Kilmarnock Main)	4 ft. to 1	0	0
Strata	2	3	0
Low Maid Coal	0	2	6
Strata	20 fms. to 30	0	0
Coal	irregular		
Strata	37	0	0
Coal (with stone in centre of the seam)	0	2	3
Strata with a thin coal-seam	15	0	0
Coal (Twenty-fathom Coal)	0	2	3
Strata	3	0	0
Coal (Seventeen-fathom Coal)	0	2	3
Strata	17	0	0
Lugar Black-band Ironstone	0	2	0

The Ell Coal at Gilmilnscroft has the following section:—

	Ft.	Ins.
Top Coal	3	10
Sandstone	12 ins. to 2	6
Bottom Coal	1	8

It was found there of a very good quality, as shown by the following analysis:—

Analysis of Gilmilnscroft Ell Coal

Hydro-carbons	33.13	per cent.
Fixed Carbon	54.58	,,
Sulphur	.38	,,
Ash	1.02	,,
Water	10.89	,,

It has recently been opened up at Auchinleck, but has not been found of such good quality. At Cumnock a sheet of intrusive whin occupies the position of the Ell Coal, and to the west of Cumnock, where the coal is not burnt, it is found to be of inferior quality, containing sometimes as much as 12 per cent of ash.

The Main Coal has been very extensively worked throughout the whole district. It is a first-class house-coal, and is known in the market as the "Bute Jewel" or the "Boswell Jewel".

It has an average thickness of 4 feet, but at Gilmilnscroft it was 5 feet 8 inches thick, with a daugh holing about 20 inches from the bottom.

The Claud Coal is a strong, hard coal of fairly good quality.

The Maid Splint Coal is a first-class furnace coal, and has been extensively worked for that purpose. The following is an analysis of this seam:—

Hydro-carbons	32.51 per cent.
Fixed Carbon	53.68 „
Sulphur	.38 „
Ash	5.39 „
Water	8.04 „

The roof of the Maid Coal consists of weak blaes and is somewhat difficult to maintain.

The two seams marked Twenty-fathom Coal and Seventeen-fathom Coal appear to correspond with the Kilwinning Ell and Main Coal Seams. They have recently been opened up in some of the old ironstone pits, and have been found of very good quality for use in the blast-furnaces.

The Coal-measures of Cumnock and Lugar district stretch northwards by Auchinleck to Catrine and Sorn, and continue in a narrow strip surrounding the Permian rocks of Mauchline. At Auchinleck shafts have been sunk by Messrs. William Baird & Company, and the coal is there being vigorously developed. The area from Auchinleck to Sorn and Catrine has not yet been opened up.

Recent borings on Sorn and Ballochmyle estates appear to prove that the coal-seams are in good workable condition, one seam being over 6 feet thick and of good quality, and if a railway connection were provided, the district should soon become an important source of coal production. The only working of which I am aware in the Upper measures was in a thin seam near Sorn Castle. There are no records to show the date at which the coal was worked, but it must have been a very long time ago—probably 200 years. The section of the seam is:—

	Ft.	Ins.
Coal	1	6
Fireclay	1	3
Coal	1	8

This seam occurs in strata which are coloured on the Ordnance Survey Geological maps as the Upper Sandstones overlying the Coal-measures. There is some difficulty in determining the exact stratigraphical position of this coal and of the seams found in the above-mentioned bores, and future developments will no doubt throw some interesting light on the subject. North-westwards from Sorn and Catrine the Coal-measures appear to thin out, and no workable seams have been found in that strip. In 1886 some bores were put down through these measures, about the point where the Glasgow and South-Western Railway crosses them north of Mauchline, but nothing of importance was discovered. Continuing farther westward in the same strip of Coal-measures, the only record I can find of any coal-workings is the statement in the Geological Survey memoir that "Two coals (one of them a gas coal and the other a household coal 3½ feet thick) have been worked at Adamhill".

Between that point and the coast the Coal-measures open out into a wider area at Symington and Dundonald. So much of the Symington and Dundonald coal-field is covered by intrusive igneous rocks, that very little is known regarding the underlying coals. At one or two places coal has been wrought underneath the basalt at Dundonald. To what extent the basaltic sheets have broken through the strata, and destroyed the coal-seams, can only be proved by boring and development work. There are many other districts which show as much basalt at the surface, and yet the coals are found to be workable; but the presence of the basalt, together with the absence of railway facilities, is rather discouraging to any exploring enterprise.

The Geological Survey express the following opinion regarding this district:—"The Coal-measures are, as yet, little known. They have been much broken up by masses of igneous rock, of which the Dundonald hills are a conspicuous example; and the coal-seams are to a large extent destroyed, though there may be among them, here and there, patches of coal which will eventually be worked."

The Dundonald whinstone appears to continue westward towards the coast, between Troon and Irvine. The harbour at Troon is built on a basaltic intrusion, and at several points along the shore, to the north of Troon harbour, masses of whinstone can be seen projecting through the sand. Some recent attempts to work the coal at Stewarton, between Dundonald and Irvine, have proved that the strata there are also much disturbed and invaded by the whinstone.

AYR COAL-FIELD.—The section of the coals worked in the Ayr and Annbank district is given in the following table, in which the corresponding seams at Cumnock and Kilmarnock are also shown:—

Section of Ayr District				Corresponding Seams at Cumnock.	Corresponding Seams at Kilmarnock or Kilwinning.
	Fms.	Ft.	Ins.		
Upper Red Sandstones with intrusive whin					
Ell Coal ... ... 2 ft. to	0	3	4	Ell Coal	M'Naught
Strata	12	0	0		
Crawfordstone Coal ...	1	1	0	Main Coal	Tourhall
Strata	8	0	0		
Three-Dirt Coal ... 5 ft. to	1	1	0	Claud Coal	Stone Coal
Strata	12	0	0		
Diamond Coal	0	3	0		
Strata ... 6 fms. to	8	0	0		
Jewel Coal	0	2	9		
Strata ... 5 fms. to	6	0	0		
Ayr Hard or Splint	0	4	6	Maid Coal	Main Coal
Strata	22	0	0		
Coal	variable				Ladyha'
Strata	20	0	0		
Coal	variable				Kilwinning Ell
Strata	16	0	0		
Coal	variable				Kilwinning Main
Strata					
Black-band Ironstone position					

Overlying the Ell Coal there is, throughout a great part of the district, a sheet of intrusive whinstone, varying in thickness from 10 to 30 fathoms. The seam has been destroyed by this whin throughout a considerable area, but occasionally the coal is found in an anthracitic condition.

The Crawfordstone Coal is of fair quality, and has been extensively worked. The following is an average section of the seam:—

Roof Freestone Plies

	Ft.	Ins.
Blacks ... ... 0 inches to	3	6
Breast Coal	4	4
Parting	0	3
Bottom Coal	1	6
Fireclay	1	6
Coal	0	10

It receives its local name from the farm of Crawfordstone, near which it crops out on the banks of the river Ayr. It is also known as the Main Coal.

The Three-Dirt Coal is also known as the Ayr Soft or Five-foot Coal. In common with most of the seams in the district it is divided by bands of dirt, as shown by the following section:—

	Ft.	Ins.
Inferior Coal	0	10
Good Coal	2	4
Daugh	0	5
Coal	2	0
Daugh	0	7
Coal	1	4

The Diamond Coal is divided into two portions by a fireclay parting. The upper portion, about 1 foot 10 inches thick, is of very good quality, but the lower portion is somewhat inferior.

The Ayr Hard or Splint Coal is the most valuable seam in the section, and has been very extensively worked. It is now exhausted in the vicinity of Ayr and Drongan, but there is still a large area available in the northern portion of the coal-field. At Drongan it was affected by an intrusive whin, and is there found as a blind coal. The general section of the seam is as follows:—

	Ft.	Ins.
Fireclay	3	6
Coal	2	6
Parting...	0	1
Coal	2	3
Daugh	0	2

The lower seams have not been worked in recent times, but there are some old outcrop workings which seem to indicate they were worked to a small extent for hill-sale. For instance, at Coylton there are some old pits, the positions of which are shown on the Geological Survey maps, that have worked a coal beyond the outcrop of the Ayr Hard Coal. At Trabboch a pit was sunk to the Ladyha' Coal position, but it was there found to be worthless. I am informed that a bore was put down below this position, and got a coal 2 feet 8 inches in thickness, about 20 fathoms below the Ladyha'. The coal was said to be a workable subject. It corresponds in position with the Kilwinning Ell Coal.

In a report by Mr. Robertson, mining-engineer, on a property to the east of Coylton, it is stated that there is a coal 40 fathoms below the Ayr Hard, and this would correspond with the above-mentioned seam. These lower seams do not possess any great value in the meantime, but they will doubtless be worked in the future.

Between Ayr and Prestwick there have been no coal-workings in recent years. In Sir John Sinclair's *Statistical Account of Scotland* (1791) it is stated that there are two seams of coal in the south part of Prestwick lands. The upper seam was met with at a depth of 6 to 7 fathoms, and had been worked for thirty years, and was exhausted. The coal was stated to be soft and foul. The second seam was met with at a depth of 33 to 40 fathoms, was 4 feet 6 inches thick, and of a hard, splintery nature. Workings had been carried on for twenty years, and the seam was exhausted south of the Kingcase dyke. An important feature of this district is the Kingcase dyke. This is an extensive basalt dyke running east and west from the shore at New Prestwick, inland by St. Quivox. It has been a general belief in the district that a 60-fathom fault ran along the course of this dyke, and that no coals were to be found north of it. It is difficult to say how this belief originated, but there is no doubt that it has been the means of retarding the development of the district. Writing in 1869 Sir Archibald Geikie said: "There does not appear, however, to be any good foundation for this supposition. A coal believed to be the Splint or Hard Coal of Ayr has been found in several bores between Prestwick and Kingcase, at depths varying from 28 to 45 fathoms. If there be any fault along the line just mentioned it does not throw out the coals, nor sink them to a great depth on the north side. The practicability of working coals does not depend on the existence of this fault but on the quality and extent of the seams themselves, and for this information further borings are necessary."

In spite of this pronouncement coal-masters seem to have been too much frightened by the bogey of local belief to attempt working this field until within the last few years. In 1897 the Auchincruive Colliery was established at a point to the north of the Kingcase fault, and all the seams of the above section have been found of at least average thickness and quality, thus proving the correctness of the opinion above quoted.

Overlying the Ell Coal throughout the whole of the Auchincruive district there is a sheet of intrusive basalt corresponding with the whin above the Cumnock Ell Coal, and apparently corresponding also with the whin above the Lanemark Gas Coal. It has been proved by many pits and bores in the neighbourhood of Auchincruive, and has a thickness varying from 10 to 30 fathoms. At places it comes close down on the Ell Coal and destroys the seam.

There appears to be no doubt that this is an intrusive whin, but it is very remarkable that, throughout such a wide area, an intrusive sheet should be found occupying the same stratigraphical position.

There are also many other intrusive sheets more local in their occurrence, whereby the coal-seams are more or less destroyed. Occasionally the action of the whin has been beneficial, causing the coals to become steam coals or even anthracite.

In addition to the "floating whins" there are numerous basalt dykes running in a north-west and south-east direction. Sometimes they run almost east and west. They vary in thickness from only a foot or two up to 15 or 20 yards. As a rule they do not run along lines of faults, but in many cases they cut across large faults without any sensible deviation. They cut through all the rocks from the Lower Silurians to the Permian Sandstones of Mauchline. They must therefore have been intruded at a later date than the Permian period, and there is reason to believe that they date from the Miocene period. It may be mentioned here that the Water of Ayr Hone-stones owe their peculiar property to the action of a sheet of intrusive whin. The stone consisted originally of a pale-gray shale, but it has been baked and hardened by the heat of the whinstone.

The Hone-stone is being worked at Muklesdale and Sundrum, near Tarbolton, and gives employment to 14 men underground and 12 men above-ground.

THE KILMARNOCK AND GALSTON COAL-FIELD occupies the valley of the River Irvine from Kilmarnock and Hurlford to Newmilns, a distance of about 7 miles. The coals occupy a syncline which at Kilmarnock is about 3 miles wide, and narrows down to only ½ mile wide at Newmilns. On either side it is bounded by large east-and-west faults. The southern fault has a throw of from 150 to 200 fathoms. To the south of Hurlford that fault throws the basement beds of the Calciferous Sandstone series into contact with the outcrop of the Main Coal, and south of Galston the interbedded traps of the Old Red Sandstone period are found in contact with the Upper Red Sandstones of the Coal-measures.

The whole of the Carboniferous series is thus thrown out; but considering that the lower portions of that series are probably thin at this point, the displacement caused by the fault need not exceed 250 to 300 fathoms.

The northern boundary of the coal-field is also formed by an east-and-west fault which, at Loudoun Castle, is of sufficient size to throw the Upper Red Sandstones into contact with the Carboniferous Limestone series—thus representing a displacement of something like 150 fathoms.

As the coal-field is everywhere bounded by faults, there is no point where the regular succession of the strata can be traced so as to show the probable thickness of the underlying Carboniferous Limestone series, and there is no evidence to indicate the presence of the Millstone Grit.

The sections of the coals at Kilmarnock and Galston are as follows:—

KILMARNOCK SECTION

	Fms.	Ft.	Ins.
M'Naught Coal	0	2	6
Strata	6	0	0
Tourhall Coal	0	4	0
Strata	15	0	0
Major Coal	1	0	0
Strata	13	0	0
Stone Coal	0	5	0
Strata	7	0	0
Coal	0	1	6
Strata	2	0	0
Main Coal	1	2	0
Strata with several thin seams corresponding with the Kilwinning Coals	65	0	0
Limestone Measures ...			

GALSTON SECTION

	Fms.	Ft.	Ins.
M'Naught Coal ...	0	3	6
Strata	7	0	0
Tourhall Coal	1	0	0
Strata	13	0	0
Major Coal	1	0	0
Strata	6	0	0
Stone Coal	0	5	0
Strata	7	0	0
Coal	0	1	0
Strata	7	0	0
Main Coal	1	1	0

The M'Naught Coal is of fairly good quality, generally with a good rock roof. It is now practically exhausted in the district. The Tourhall Coal is a good house coal and has been very extensively worked. The section of the seam is as follows:—

	Ft.	Ins.
Top Coal	4	6
Daugh	0	6
Bottom Coal	1	6

The holing is in the daugh, and the seam is worked on the stoop-and-room system. The Major Coal is generally a good house coal, although in some areas it is only of a second-class quality.

The Stone Coal contains three partings, as shown in the following section:—

	Ft.	Ins.	Ft.	Ins.
Coal			1	3
Fireclay	0	4		
Coal			0	6
Fireclay	0	6		
Coal			1	0
Fakes ... 9 inches to	3	0		
Coal			2	6
			5	3

The 2-foot-6-inch coal is worked by longwall, and the 1 foot of coal above it is partially recovered in the brushing. The upper portions are generally sacrificed, except what may be recovered in the second brushing, or when redding falls. This seam is of a hard, splinty nature, suitable for furnaces, or for shipment coastwise.

The Main Coal is the best house coal of the district. It is sometimes as much as 11 feet thick with partings, and to the west of Kilmarnock it splits up into three seams, viz. the Splint, Turf, and Wee. At Galston it consists of one seam 7 feet thick, without any parting. The following is an analysis of the Main Coal from Gauchallan Colliery:—

Specific Gravity, 1.241

Volatile Hydro-carbons	34.13	per cent
Fixed Carbon	52.62	,,
Sulphur	.60	,,
Ash	2.14	,,
Water	10.51	,,
	100.00	,,

SALTCOATS AND KILWINNING COAL-FIELDS.—The following sections of the Saltcoats and Kilwinning coal-fields are taken from the Geological Survey memoir.

SALTCOATS	FERGUSHILL	Ft.	Ins.	KILMARNOCK
——	——			Red Sandstone Grout Strata.
——	——			M'Naught Coal.
Bowbrig Coal ...	Tourha' Coal ...	3	0	Tourhall Coal.
Strata ...	... ...	88	0	
Crawford Coal	Major Coal ...	4	0	Major Coal.
Strata ...	... ...	89	6	
Five-quarter Coal	Five-quarter Coal	5	8	Stone Coal (Blind Coal of Caprington).
Strata ...	... ...	64	0	
Parrot Coal ...	Splint or Parrot Coal	3	2	Main Coal of Kilmarnock and Hurlford.
Strata ...	... ...	1	1	
Turf Coal ...	Turf Coal	3	9	
Strata ...	... ...	2	4	
Little Coal ...	Wee Coal	1	9	
Strata ...	Strata	110	0	
	Oil Shale	1	4	
	Strata	27	0	
Davis Coal ...	Ladyha' Coal ...	2	9	
Strata ...	... ...	50	0	
Little Parrot Coal	Ell Coal	2	9	
Strata ...	... ...	66	0	
Lower Little Coal	Stone or Gypsy Coal	3	8	
Strata ...	... ...	34	0	
Main Coal ...	Main Coal	4	6	
Strata ...	... ... 50 to	60	0	
Raise Coal ...				

The Raise Coal at Saltcoats is only a short way above the highest of the Limestone beds. Apparently the Millstone Grit series is altogether awanting in this part of Ayrshire.

The coal-field along the coast from Saltcoats to Irvine has not yet been developed to any considerable extent. This is accounted for by the fact that it is supposed to be very much interrupted by intrusive igneous rocks, and also that it is covered by blown sand, which in many places would be very difficult to sink through. Farther inland, at Caprington, the effect of the whinstone has been more favourable, converting the Stone Coal into a valuable anthracite. The following section of Caprington No. 34 shaft gives a good idea of the position and effect of the whinstone:—

SECTION AT CAPRINGTON

			Fms.	Ft.	Ins.
M'Naught Coal (exhausted)			0	3	4 at 12 fms.
Strata			7	0	0
Tourhall Coal	Top Coal (burnt, useless)	1 ft. 2 ins.			
	Whinstone	30 ft. 0 ins.			
	Bottom Coal	10 ins.			
Strata			17	0	0
Major Coal (exhausted)			0	3	4
Strata			12	0	0
Stone Coal	Anthracite Coal	1 ft. 10 ins.	0	3	4
	Holing				
	Anthracite Coal	1 ft. 6 ins.			

Whinstone occupying the position of the lower seams.

An analysis of the Caprington Anthracite made by Dr. Wallace in 1879 gave the following results:—

Specific Gravity, 1.367

Fixed Carbon	83.9 per cent.
Volatile Matter	11.1 ,,
Ash	3.2 ,,
Water	1.8 ,,
	100.0

The coke contained .54 per cent of sulphur.

The blind coal of Caprington has long been in use throughout the whole of Scotland for such purposes as malting and drying oat grain, but it is now practically exhausted. The colliery is still partly unwatered by an old atmospheric pumping-engine working with steam of 1-lb. pressure above the atmosphere.

To the north-west of Caprington the whinstone either dies out or occupies a lower horizon, and the lower seams are found in their normal condition.

The Splint, Turf, and Wee Coals come very close together, and are excavated in one working on the stoop-and-room system.

The Section at Fairlie Colliery is—

	Ft.	Ins.	Ft.	Ins.
Splint Coal			3	0
Stone	0	9		
Turf Coal Upper Ply			2	0
Parting	0	4		
Turf Coal Lower Ply			1	10
Sandstone	0	10		
Wee Coal			1	6
	1	11	8	4

The Splint Coal is left on for a roof in the first working, but is recovered in the stooping. Those seams are the same as the Main Coal of Kilmarnock.

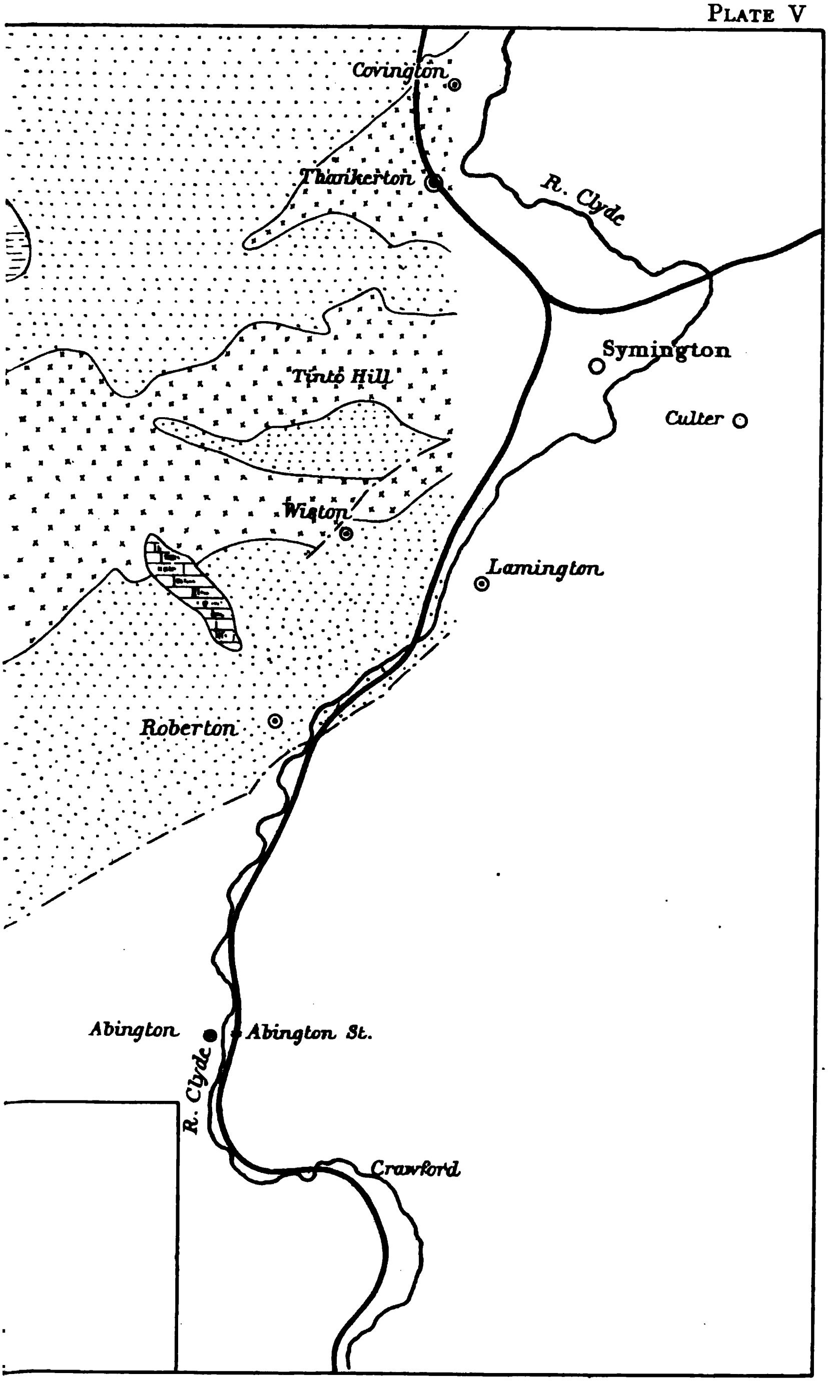
The central portion of the Ayrshire basin is occupied by an area of about 28 square miles of rocks belonging to the Permian series. Mention has already been made of the volcanic necks of Permian age which are found scattered throughout the Ayrshire coal-field. The lavas and ashes which must have been emitted from these vents have, throughout most of the coal-field, been removed by denudation, and the vents, or necks, are now the only traces left of the Permian volcanic activity.

In the central part of the basin, however, the Coal-measures have been depressed to such an extent that the Permian volcanic rocks which occupied the hollow have not been reached by the denuding agencies. At the close of the volcanic period this same area was occupied by a lake in which were deposited beds of sandstone and shale which are distinguished by a peculiar, bright, brick-red colour

The outcrop of the volcanic zone appears as a ring circling round the Permian Sandstones by Ochiltree, Catrine, Mauchline, and Tarbolton.

The Coal-measures strata are everywhere seen dipping under these volcanic rocks, and how far the coal-seams may be found stretching under them in a workable condition is an interesting speculation. South of the Permian iles to an inch

PLATE V



area the coal-seams are being worked at Cumnock, Auchinleck, Auchincruive, &c., but a change evidently occurs in passing northwards, as the Coal-measures emerge from below the northern edge of the Permian rocks in an impoverished condition, and contain little or no workable coal.

In addition to this thinning out of the coal-seams there is also a strong probability that they are invaded by volcanic intrusions both of Permian and later ages.

A deep bore is being put down through the Permian volcanic rocks near Tarbolton, but the result of this bore is not yet available for publication.

In the report of the Royal Commission on Coal, published in 1871, Sir Archibald Geikie gives the following opinion regarding the probability of finding coal beneath the New Red Sandstones at Mauchline:—

"The centre of the Ayrshire coal-field is covered with a circular patch, or basin, of Permian rocks occupying an area of about 28 square miles. The centre of this basin consists of a mass of nearly horizontal brick-red sandstones, and its margin of a ring of volcanic rocks, which underlie the sandstone. The total thickness of these rocks is probably on an average of at least 1250 feet. Underneath them lies another group of red sandstones, containing no coal but forming the highest division of the Carboniferous formation, and varying in thickness up to probably 1000 or 1200 feet. Hence, the coal-bearing strata of Ayrshire are here covered by a mass of overlying rocks, which, in the centre of the Permian basin, are probably more than 2000 feet thick. For reasons given by me before the Coal Commission, there is reason to suspect that, though the coal-seams of the Ayrshire field extend under the Permian basin, they would not be everywhere found in a workable condition. This would be due partly to a thinning away of the coals, and partly to the destruction caused by the igneous rocks, but there can hardly be any doubt that many square miles of ground containing workable coal remain still untouched in the centre of Ayrshire."

CHAPTER IV

Renfrewshire

During recent years the quantity of coal produced in Renfrewshire has been very small, especially since the Pollok Colliery was abandoned in 1899. The whole output of coal from the county in 1900 was only 13,104 tons. The production of ironstone, however, is still an important industry in the county. In 1900 the output of ironstone was 151,545 tons, which is about equal to the output of ironstone in Lanarkshire, and is half the output of ironstone in Ayrshire. The principal ironstone-workings are by Messrs. Merry and Cunninghame at Inkermann, near Paisley, and by Messrs. William Baird & Co. at Victoria Pit, Nitshill.

A small area of the Upper Coal-measures extends into the county of Renfrew, at Strathbungo, containing the outcrops of the Kiltongue and Virtuewell Coals, but with that exception the coals and ironstones of Renfrewshire all belong to the Carboniferous Limestone series. Two seams of Black-band Ironstone have been very extensively worked, and these occupy a horizon corresponding with the Garscadden Upper and Lower Black-band Ironstones.

At Pollok, near Glasgow, a series of coals was worked out many years ago, which occupied a position corresponding with the Possil coal-seams.

Limestone is also being worked in Renfrewshire, the output during 1900 from mines and quarries amounting to 37,288 tons. The principal working is in the Upper or Arden Limestone, which has special properties as a hydraulic lime.

The following is a general section from the Upper Limestone to the base of the Carboniferous Limestone series:—

General Section of Renfrewshire Coal-field

		Fms.	Ft.	Ins.
	Arden Limestone and Coal	1	3	0
	Strata	26	0	0
	Orchard Limestone	1	0	0
	Strata	22	0	0
	Cowglen or Index Limestone	0	2	0
	Strata	9	0	0
Worked at Pollok. Position of the Possil Coals.	Sclutty Coal ... 1 ft. 6 ins. to	0	3	0
	Strata	24	0	0
	Smithy Coal	0	1	6
	Strata	3	0	0
	Rough Coal	0	2	8
	Strata	2	0	0
	Stinking Coal	0	1	9
	Strata	3	0	0
	Geordie Coal	0	2	2
	Strata ... 10 fms. to	30	0	0
	Two-foot Coal	0	2	2
	Strata	3	0	0
	Stone Coal	0	2	0
	Strata	11	0	0
	Radical Coal	0	2	4
	Strata	5	0	0
	Splint (or Satturland) Coal	0	2	0
	Strata			
	Black-band Ironstone (Garscadden Upper)	0	1	0
	Strata	4	0	0
	Black-band Ironstone (Garscadden Lower)	0	1	0
	Strata (with position of the Kilsyth Coking Coal)	44	0	0
	Clay-band Ironstone (Johnstone)	0	1	7
	Strata	9	4	0
	Hosie Limestone	0	3	3
	Strata	1	1	0
	Lilie's Oil Shale and Coal	0	3	0
	Limestone	0	1	0
	Strata	0	3	6
	Clay-band Ironstone	0	0	8
	Strata	16	4	8
	Hurlet Limestone	1	1	0
	Strata	0	3	2
	Hurlet Coal	0	3	0
	Strata	20	0	0
	Lady Ann Coal (Fulton)	0	1	8

At the Victoria Pit, Nitshill, the Hurlet Coal was worked from a depth of 175 fathoms. It was at this colliery that the disastrous explosion occurred in 1851, whereby sixty-one persons lost their lives. The Hurlet Coal is still intact throughout a considerable area of Renfrewshire, but at too great a depth to offer much inducement for opening it up in the meantime.

A section of the Hurlet Seam is as below:—

	Ft.	Ins.
Limestone	4	0
Alum Shale	1	8
Coal with pyrites	5	6

The analysis of the alum shale is:—

Specific Gravity, 2.198

Sulphur	4.29	pyrites
Iron	3.79	
Peroxide of Iron	6.48	
Alumina	4.64	
	19.20	

In the early part of the nineteenth century the alum was worked by the Hurlet Alum Company, their lease expiring in 1863.

At Quarrelton, near Johnstone, there has been a remarkable thrusting action, whereby the seams of coal have been pressed together so as to overlap one another.

A detailed section taken where the coals are overlapped is as follows:—

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Greenstone	18	0	0			
Sandstone and common indurated clay alternating in thin bands ...	4	0	0			
Fireclay, with coarse Ironstone ...	2	0	0			
Coal				1	4	0
Indurated Clay	0	1	0			
Coal				1	4	0
Indurated Clay	0	2	3			
Coal				1	3	0
Indurated Clay	0	1	0			
Coal (reckoned three beds) ...				4	3	0
Indurated Clay	0	1	0			
Coal				1	4	0
Indurated Clay	0	2	3			
Coal				1	3	0
Indurated Clay	0	1	0			
Coal (reckoned two beds)				2	5	0
				15	2	0

In a paper contributed to the Wernerian Society, in 1828, by Mr. Bald of Edinburgh, it is stated that "The Johnstone colliery took fire from spontaneous ignition about the year 1808. It consisted of five distinct beds of coal, lying so close together that they might be said to form one bed of the extraordinary thickness of 40 feet. And in one place these seams were overlapping, and constituted the amazing thickness of 80 feet.

"It is also remarkable as being in a district abounding with compact greenstone, upwards of 108 feet in thickness.

"As soon as the densely heated vapour burst into a flame it towered up to the height of 70 feet, and produced a very sublime object, burning down the machinery for drawing the coals. In consequence of the extreme thickness of the coal-seam no hope existed of extinguishing the fire by means of any covering up of the shafts; but exertions were made to confine the fire to its circumscribed place, and stone walls were built in all the openings betwixt the pillars and around the fire, which walls were made air-tight by a thick coating of lime plaster. This had the desired effect, and the burning has been confined within these bounds. No doubt the fire will continue to burn within these bounds for a long period of years."

About ten years ago an attempt was made to reopen the Quarrelton Colliery, but it was not successful.

A narrow strip of the Carboniferous Limestone rocks stretches southward from Barrhead and Neilston along the line of the Barrhead and Kilmarnock railway. At Caldwell it opens out to a width of from half a mile to a mile, and coal has recently been worked at Ouplaw. The workings, however, were only on a very small scale, and did not prove a success, principally on account of the amount of water to be dealt with.

Between Barrhead and Thornliebank there is a deep basin, with a patch of Millstone Grit in the centre. Some coal-seams should be found here, but they are probably too thin to justify an expensive sinking in the meantime.

CHAPTER V

The Lanarkshire Coal-Field

More than half the output of coal in Scotland is produced from the county of Lanark, the output in 1900 amounting to 17,174,247 tons from this county alone.

There are about 250 collieries working in the county, and of these only 14 are working coals from the Lower or Carboniferous Limestone Coal-measures, so that 95 per cent of the output is coming from the Upper Coal-measures.

The coal-field takes the general form of a basin having its deepest portion in the Newton and Bothwell district. Towards the west and north the Coal-measures crop out, and are succeeded by the Millstone Grit at Glasgow, Stepps, and Glenboig.

The lower seams of the Coal-measures come to the surface in the eastern district, in the Longriggend and Shotts coal-fields.

Towards the south-east the Coal-measures are succeeded by the Limestone series at Carluke and Auchenheath.

The south-western boundary is formed by a great upthrow fault, which in the vicinity of Hamilton throws the Limestone measures in contact with the Upper Red Sandstones.

There is also a small basin at Douglas forming a separate coal-field.

The coals in the Hamilton and Bothwell basin are overlain by a thick deposit of red sandstones. At one time it was assumed that these were the Old Red Sandstones, and it was not until about 1840 that investigations revealed their true position as forming part of the Coal-measure series, and that consequently coals lay beneath them.

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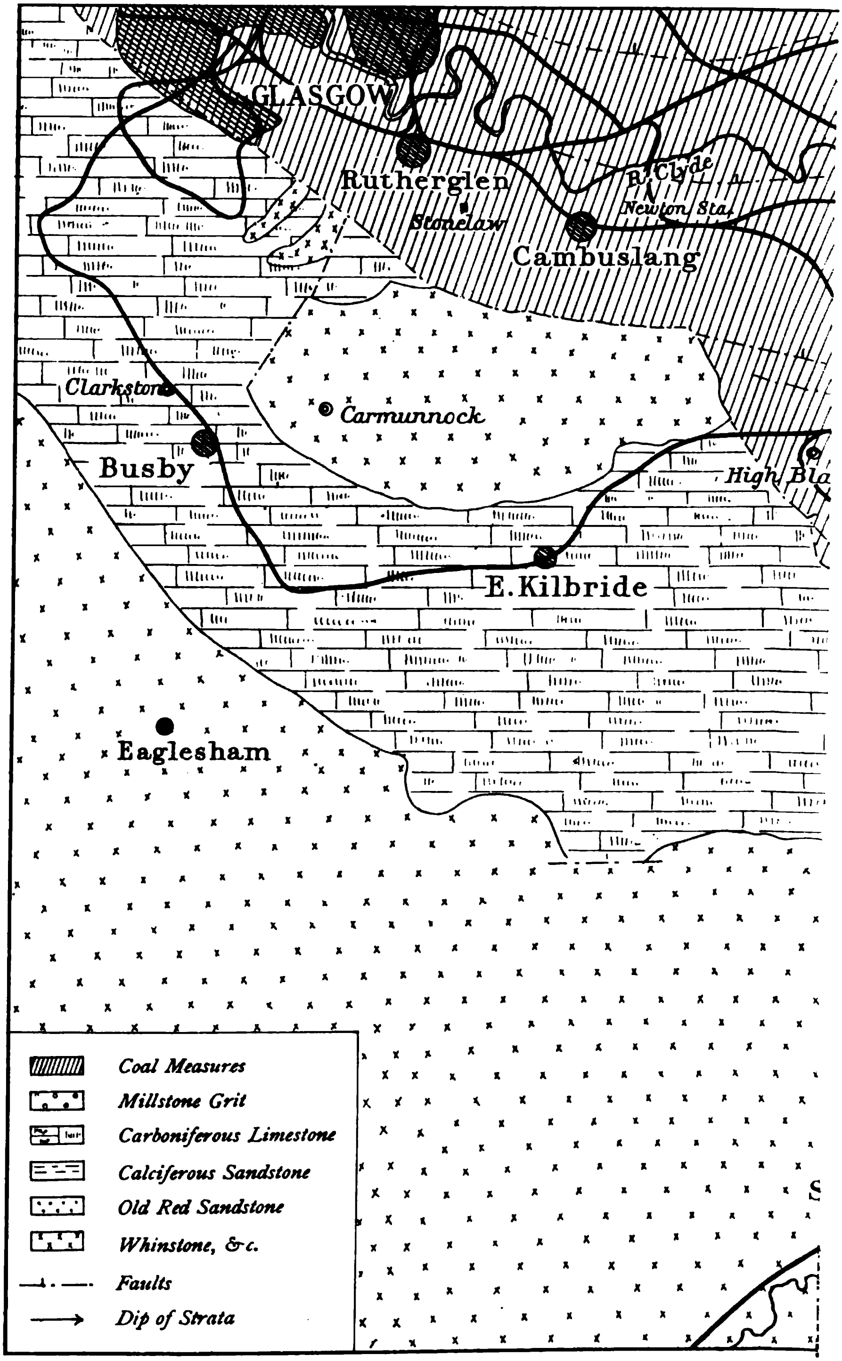

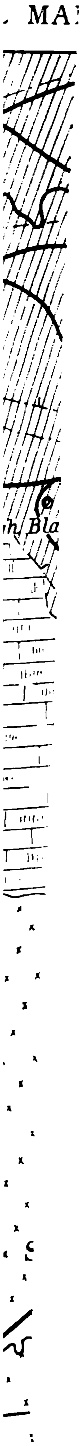

Most of the collieries in the deeper portion of the field, from Cambuslang to Hamilton, have been opened up since the year 1870, the development of the Hamilton district being very much stimulated by the introduction of the Bothwell and Hamilton railway in 1876–77.

The general section of the seams, with the average distance between them, is as follows:—

		Fms.	Ft.	Ins.
Upper Sandstones (containing several seams of coal from 6 ins. to 16 ins.), about		100	0	0
Palacecraig Ironstone				
Strata		11	0	0
Upper Coal	1 ft. to	0	4	6
Strata		18	0	0
Ell Coal	4 ft. to	1	3	0
Strata		11	0	0
Pyotshaw Coal	0 to	0	4	0
Strata	0 to	6	0	0
Main Coal	3 ft. 6 ins. to	0	4	6
Strata		10	0	0
Humph Coal	0 to	0	3	6
Strata		5	0	0
Splint Coal	2 ft. 6 ins. to	1	0	0
Strata	0 to	4	0	0
Virgin or Sourmilk Coal	0 to	0	3	0
Strata		7	0	0
Mussel-band Coal	0 to	0	4	0
Strata, containing Airdrie Black-band Ironstone, Cleland Rough-band Ironstone, and a Soft-band Ironstone. These ironstones are local in their occurrence		16	0	0
Virtuewell Coal	1 ft. 4 ins. to	0	3	0
Strata		5	0	0
Bellside Black-band Ironstone	0 to	0	0	6
Strata		7	0	0
Mussel-band Shale position		0	1	0
Strata		7	0	0
Kiltongue Coal	2 ft. 6 ins. to	1	0	0
Strata		3	0	0
Coal (sometimes a cannel)	6 ins. to	0	2	0
Strata		7	0	0
Upper Drumgray Coal		0	2	4
Strata		11	0	0
Lower Drumgray Coal		0	2	0
Strata, containing position of Shotts Gas Coal, and Crofthead and Armadale Coals		45	0	0
Slatey-band Ironstone	5 ins. to	0	1	0

The Upper Coal Seam is about 4 to 4½ feet thick at Govan and Stonelaw, and was there an excellent house coal. At Bardykes it is 2 feet 9 inches thick, and has been extensively worked. Throughout the other parts of Lanarkshire it is somewhat irregular, and is frequently known as the "Wandering Coal". In the Hamilton district it is only about 1 foot thick, and has not been worked. In the Larkhall district it is about 2 feet 6 inches thick, but contains one or two dirt partings which detract very much from its value.

The Ell Coal has been very extensively worked throughout the whole area, and is now in many places becoming exhausted. It is of exceptionally good quality in the Hamilton and Wishaw districts, and is in great demand for household purposes. In many collieries the top part of the Ell Coal, known as heads, is of poorer quality than the rest of the seam. This head coal varies from 2 feet to 3 feet in thickness. In far too many instances the whole of it has been wantonly sacrificed in the effort to secure greater immediate profits from the working of the principal part of the seam. In the Larkhall district it is frequently 10 to 12 feet thick, but the upper portion is not of such good quality. In that district there is frequently a very soft fireclay overlying the seam, and it is necessary to leave on from 2 to 4 feet of coal to support the roof.

In the Airdrie district the seam is frequently split into two seams by a parting, varying from 1 to 4 feet. It is there of a hard, splinty nature, more suitable for furnace and manufacturing purposes than as a house coal.

The Pyotshaw Coal is very variable in character. At Govan and Stonelaw it is entirely absent. From Cambuslang to Hamilton it is generally found of a workable thickness. Beyond Hamilton it is more irregular, being sometimes found in patches only a few acres in extent. It is seldom a first-class coal, and is generally of a hard, splinty nature, suitable for furnace and manufacturing purposes.

Very frequently the Pyotshaw and Main Coals are found s one seam, or only separated by a few inches of fireclay. n the district lying to the north of the Monkland Canal, and in the neighbourhood of Airdrie and Rawyards, the Pyotshaw and Main Coals have been subject to the influence of great intrusive sheets of whin. At many places he coal is rendered unworkable from this cause, but at others it has been converted into a steam coal, and occasionally into an anthracite. The burning, however, is very erratic, and the seam does not maintain the same condition over any considerable area.

The Main Coal is a bright-black coal, with a cubical fracture and a white ash. It is fairly regular in thickness and quality throughout the whole county, and is used as a second-class house coal, and is also used for manufacturing and locomotive purposes. It contains, as a rule, three ribs of hard, splinty coal of considerable thickness. In some districts a rib of cannel coal of fair quality is present, and over a large area the thickest of the splint-coal ribs is found as a bastard gas coal, known locally as "pugs". The presence of the pugs deteriorates the quality of the coal for general purposes, but at many of the collieries they are picked out and sold separately for gas-making purposes. They yield a fair quantity of gas of about 19-candle power, but the coke obtained is soft and of little value. At some collieries the splint coal is separated from the free coal by hand picking at the surface—the splint being sold as steam coal, and the free coal being sold as house coal.

The Humph Coal has been worked at Govan and Stonelaw, and also at Rawyards and Airdrie. At Wishaw and Motherwell the coal is from 1 foot 6 inches to 2 feet thick, but above it there is about 2 feet of fireclay of superior quality, and the coal (which is of first-class quality), along with the fireclay, makes a profitable working. In the Baillieston district the Humph Coal varies in thickness from 11 inches to 16 inches. At Whistleberry Colliery and

Clyde Colliery, to the west of Hamilton, it is 3 feet thick, and in the Cadzow pits it was found 2 feet 8 inches thick. It has been hitherto neglected owing to the facility with which thicker coals of better quality can be obtained, but no doubt it will be worked more or less in the future. In New Monkland it is frequently found as a smithy coal, and has been extensively worked for that purpose. The section of the seam in that district is:—

	Ft.	Ins.
Inferior Coal	0	8
Parting	0	3
Good Coal	2	0

The inferior coal is generally left on to form the roof of the workings.

The Splint Coal is the most persistent of all the seams, and has been very extensively worked for smelting iron in blast-furnaces, for which purpose it is eminently adapted. It is also used for gas-making. The Splint Coal seam is approaching exhaustion, and already the supply is barely sufficient to meet the demands of the blast-furnaces. The coal is of a strong splinty nature, with a dull blue-black colour. It splits easily along the planes of stratification, but is more difficult to break vertically. The coal is thus got in large lumps, with a very small proportion of dross. In the Uddingston, Hamilton, and Wishaw districts there is usually a layer of cannel coal associated with this seam.

The cannel coal is of black colour, with considerable lustre and smooth conchoidal fracture. It is generally very erratic in thickness, varying in a short distance from 1 inch to 18 inches. It is rather remarkable that where this gas coal occurs it forms an addition to the thickness of the seam, the thickness of the common remaining about the same whether the cannel coal is absent or present.

A section of the seam at Uddingston, where the gas coal is best developed, is as follows:—

SECTION OF SPLINT COAL AT UDDINGSTON

	Ft.	Ins.
Splint coal	1	7
Gas coal	1	3
Free coal	0	4
Gas coal	0	6
Free coal	0	4
	4	0

The Virgin Coal is frequently of very good quality as a house coal, in many places equal to the Ell Coal, although somewhat coarser and stronger. It has been mostly worked in the Baillieston, Shettleston, and Govan districts, where it is separated from the splint coal by strata varying from 3 feet to 18 feet in thickness.

It has not yet been worked to any extent in the Bothwell and Uddingston coal-field. It is there separated from the splint coal by only about 12 inches of blaes. In the Hamilton district it forms one working with the splint coal, the parting being seldom more than a few inches. In New Monkland district it is only 18 inches thick, and has been very little worked.

The Mussel-band Coal is very irregular in its occurrence. It has been worked to some extent in New Monkland parish, at Drumshangie and Dykehead, and also in the Shettleston district. It gets its name from a thin band of mussel-band ironstone, of no commercial value, found in the roof, about 4 feet above the coal.

The following is a section of the seam, as found in the New Monkland district:—

		Ft.	Ins.
Mussel-band Ironstone	... ...	0	4
Soft dark Blaes ...	... ...	4	0
Coal, splinty ...	... 2 ft. 2 ins. to	3	0
Dark Blaes ...	... 11 ins. to	1	3
Coal, free ...	... ...	1	0

The roof is very soft and requires to be closely timbered, and where the seam is thin or of poor quality it is not considered worth working, on account of the expense involved in supporting the roof.

The coal is largely used for gas-making purposes, as it gives about 11,000 cubic feet of gas per ton, with an illuminating power of about 16 candles.

A seam, which may be the Mussel-band Coal, has recently been worked to a small extent at Comedie Colliery, near Millerston, at a depth of 18 fathoms below the Virgin Coal. At Bredisholm a coal is found about 13 fathoms below the Virgin, which may correspond with the Mussel-band Coal. It has not yet been worked, but the following is the section from a bore:—

	Fms.	Ft.	Ins.
Fakes and Fireclay	1	1	6
Coal	0	1	6
Dark Blaes	0	0	5
Coal	0	1	9

At Birkrigg Colliery, Stonehouse, a coal, 2 feet thick, is found 6 fathoms below the splint; and another coal, 1 foot 4 inches thick, about 14 fathoms farther down, either of which seams may correspond with the Mussel-band Coal. This seam has also been found at various other points throughout Lanarkshire, and will doubtless come to be more extensively worked when the thick seams are approaching exhaustion.

I quote the following description of the Airdrie Black-band and Soft-band Ironstones from a paper by Mr. James Prentice, published in the *Transactions of the Institute of Mining Engineers*.[1]

"The Black-band Ironstone lies 27 feet below the Mussel-band Coal Seam. Although the black-band ironstone was discovered by Mr. Mushet in the year 1805, and in a few years afterwards its great adaptability for use in the blast-furnace had been fully proved by experience, yet it did not come into very extensive use in the earlier years of the century. This may be easily accounted for by the comparatively small quantities of ore required to keep the furnaces then built in operation. But when Mr. Neilson's great invention of the hot-blast was introduced in 1828, taken along with the erection and starting of such important works as Gartsherrie, Summerlee, Langloan, and Carnbroe, a great and pressing demand at once set in for this splendid iron ore, with the result that almost every available acre of ground in the parish was eagerly competed for and taken in lease by one or other of the great iron companies. Its geological position had by this time become perfectly well known, and the exact depth to which a pit would require to be sunk to reach it could be calculated to a certainty where any of the above-mentioned coal-seams were wrought, or were known to crop out. Hence the marvellous rapidity with which the surface of the central, northern, and southern parts of the parish became dotted with pits for the working of the seam. Another important factor in this development was the making of the Ballochney railway in 1828, and of the Drumshangie branch some years later. These lines gave great facilities for the carriage of the iron ore to the furnaces, and were the means of opening up new districts for the working of the ironstone, as well as many of the other seams, which, without these aids, might have long remained unwrought. It is perhaps not too much to say that the prosperity of mining in the parish at the present day owes its origin to the impetus given to the industry by the operations in connection with the searching for, and working of, this important seam in the past. Thus, in the eager search for ironstone in the shallower portions of the fields, bore-holes were often put down over the outcrop of this seam. These bore-holes, although they may have missed the ironstone, were carried on until one or other of the seams lying below it was found. In this way a knowledge of the lower seams, with their thickness and relative geological position, was gradually acquired, which is being amply utilized at the present day. Another important advantage has been gained by the utilization of the old ironstone pits for the working of the coal-seams. In many instances throughout the parish these advantages have enabled men of moderate means to start as coalmasters who might otherwise have been unable to do so, and have added greatly to the more recent development of the coal-mining industry. The Black-band Ironstone may now be said to be wrought out. The most recent workings in the seam were about eight years ago at Darngavil.

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[1] Vol. xii, p. 440.

"Although the seam attains its greatest development, and is in its best condition in the parish, yet it does not continue to be a workable seam over the whole area represented by its geological position. Thus, in the south-eastern portion of the parish it occurs as a foul coal, about 12 inches thick, without any trace of ironstone; while in the eastern portion it dies out as a workable ironstone. Eastwards from the western side of Arden, and the eastern march of Darngavil, it is represented by about 2 inches of inferior ironstone and 14 inches of foul coal. In its northern extension the seam retains its value as an ironstone until it finally crops out in the neighbourhood of Greengairs.

"The thickness of the seam varied a little in the different parts of the field, but it averaged about 14 inches, and had a specific gravity of 2.88. The following is an analysis of the raw ironstone in its best state:—

Protoxide of Iron	48.25	per cent.
Carbonic Acid	32.91	"
Carbon	12.90	"
Combined Water	3.74	"
Phosphoric Acid	0.94	"
Lime	0.56	"
Silica	0.40	"
Magnesia	0.30	"

"According to this analysis the metallic iron contained in the ironstone is equal to 37½ per cent, or about 1500 tons of pig-iron per acre.

"An accident of a peculiar kind, arising from the calcining of a heap of this ironstone, may be here referred to. It occurred at the north-eastern corner of Dykehead, about the year 1840. A heap of black-band ironstone had been deposited on a hearth, under which the Splint

Coal seam had been previously worked, quite near the surface. After the ironstone had been kindled a sit took place, letting down the burning ironstone into the old coal-workings. This at once set fire to the stoops of coal left to support the roof, and in a short time the old underground workings were in a blaze. The conflagration rapidly extended, and all efforts to put it out failed. A conference of the neighbouring proprietors and others was called, at which it was decided to isolate the fire by cutting a deep channel round it, and carry the cutting right down through the seam on fire. This was at once set about, and a large number of navvies from all parts were got to do the work. Large cuttings were made, at some points 40 feet deep, to intersect the seam. This plan was ultimately successful, although at the completion of the work the fire had extended almost to the very place where the men were at work. A lawsuit was raised to decide who was liable for the expense incurred, and was ultimately decided against the lessees of the minerals.

"The Soft Ironstone is a peculiar seam of ironstone of poor quality, which lies about 5 feet below the black-band over a very limited area, and confined exclusively to a strip of the parish, extending from Rawyards in the south-west, to Greengairs in the north-east. At no part of this strip does the width of the ironstone exceed 600 feet. It has been wrought at Rawyards, Airdriehill, Stanrigg, and Whiterigg, but has never been a working of much value. As it was wrought in those places subsequent to the extraction of the black-band ironstone, great difficulty was experienced in keeping the roads in the seam in repair. So thin was the division between the seams that falls often took place in the soft ironstone workings, extending upwards into the old waste of the black-band ironstone workings, and leading to considerable expense and danger in carrying on the works. The seam was about 20 inches in thickness in the centre of the strip, tapering down towards the edges of the area to an inch or two, and finally disappearing altogether. The occurrence of this seam is remarkable as a geological curiosity, as it proves that before the black-band seam was formed, a long, narrow lake had extended over the area now containing the soft-band seam, which was entirely local in its nature."

In the Holytown district a coal is being worked which seems to correspond with the position of the Black-band Ironstone. The section of the seam at Dalzell Colliery is as follows:—

	Ft.	Ins.
Coal	0	10
Stone	0	7
Coal	0	2
Stone	0	2
Coal	1	2

At Knownoble Colliery, Cleland, the Black-band Ironstone is generally represented by a coal-seam about 15 inches thick, but running across the property there is a strip about 80 yards wide, in which the coal is 3 feet thick, thinning off at the edges to the usual thickness of 15 inches. At Quarter Collieries, Hamilton, a black-band ironstone was extensively worked and smelted at the Quarter furnaces. Those furnaces were suspended in 1886, and since then the ironstone has not been worked. The thickness was 10 inches of ironstone, with 4 inches of coal underneath. At Allanton Collieries, in the same locality, a seam of black-band ironstone is found, 1 foot 9 inches thick, about 13 fathoms below the Virgin Coal. In the same colliery there is a seam of coal 2 feet 6 inches thick, 6 fathoms below the Black-band.

The coal-seams above the Virgin Coal are generally known throughout Lanarkshire as the Upper Seams. The Under Seams may be divided conveniently into two groups: first, the seams from the Virtuewell to the Lower Drumgray; and second, the seams between the Lower Drumgray and the Slatey-band Ironstone.

The geological development of the Lower Seams appears to be progressive, going from west to east. Thus, near Glasgow, Carntyne and Millerston, the Virtuewell and Kiltongue Coals are only found at 1 foot 6 inches to 2 feet 6 inches thick, and all the seams below the Kiltongue are either absent or very thin. At Dalmarnock, near Glasgow, a bore was put down 80 fathoms below the Splint Coal, but no workable seams were found. A bore was also put down at Hamilton Farm, near Cambuslang, to the same depth, and only one seam over 2 feet thick was found. The Drumgray Coals are found at Baillieston, from 1 foot 6 inches to 1 foot 9 inches thick. Farther east the Kiltongue Coal becomes 6 feet thick, and the Drumgrays about 3 feet thick. Those seams are all workable subjects throughout the rest of the district to the east in the Airdrie and Shotts coal-fields. They are also being opened up farther south at Larkhall and Stonehouse. In the Bothwell and Hamilton district the Lower seams are of little or no value. A bore at Greenfield passed through the position without meeting any workable seam. At Hamilton Palace Colliery a mine is being driven, intersecting the lower seams.

At Cleland Colliery a bore was put down from the Virtuewell Coal pavement to a depth of 107 fathoms. At that depth a seam of limestone was met with, which may represent the Castlecary or Levenseat limestone. The only coal-seam found in the bore was the Drumgray Coal, 1 foot 8 inches thick, at 35 fathoms below the Virtuewell.

The seams below the Drumgrays are found in the eastern portion of Lanarkshire, in the Shotts district, from which point they become thicker and more numerous towards the north-east in the Armadale and Falkirk coal-fields. As previously mentioned, this Lower series of coals becomes more developed in the eastern coal-fields of Fife and Edinburghshire.

As an indication that conditions favourable for the formation of coal-seams commenced at an early period in the eastern part of the Lanarkshire district, it is worth observing that seams of coal have been found in the Millstone Grit, where that formation comes to the surface at the eastern outcrop of the Coal-measures at Bathgate, and to the north-east of Falkirk.

The first seam of the Lower series is the Virtuewell Coal. This coal is generally a bright black coal, somewhat coarser than the Ell Coal. It is generally a fairly good house coal, and in some districts might be described as first class. This seam corresponds with the Johnstone Coal of the Slamannan coal-field. It has been extensively worked throughout the whole district between Coatbridge and Slamannan, and is now nearly exhausted in those localities.

At Stanrigg, near Airdrie, oil-works were erected to treat a band of oil-shale about 8 inches thick, found immediately above the Virtuewell Coal.

In the Newarthill and Cleland district there is also a shale and gas coal associated with the Virtuewell Seam. The following is a section of the working:—

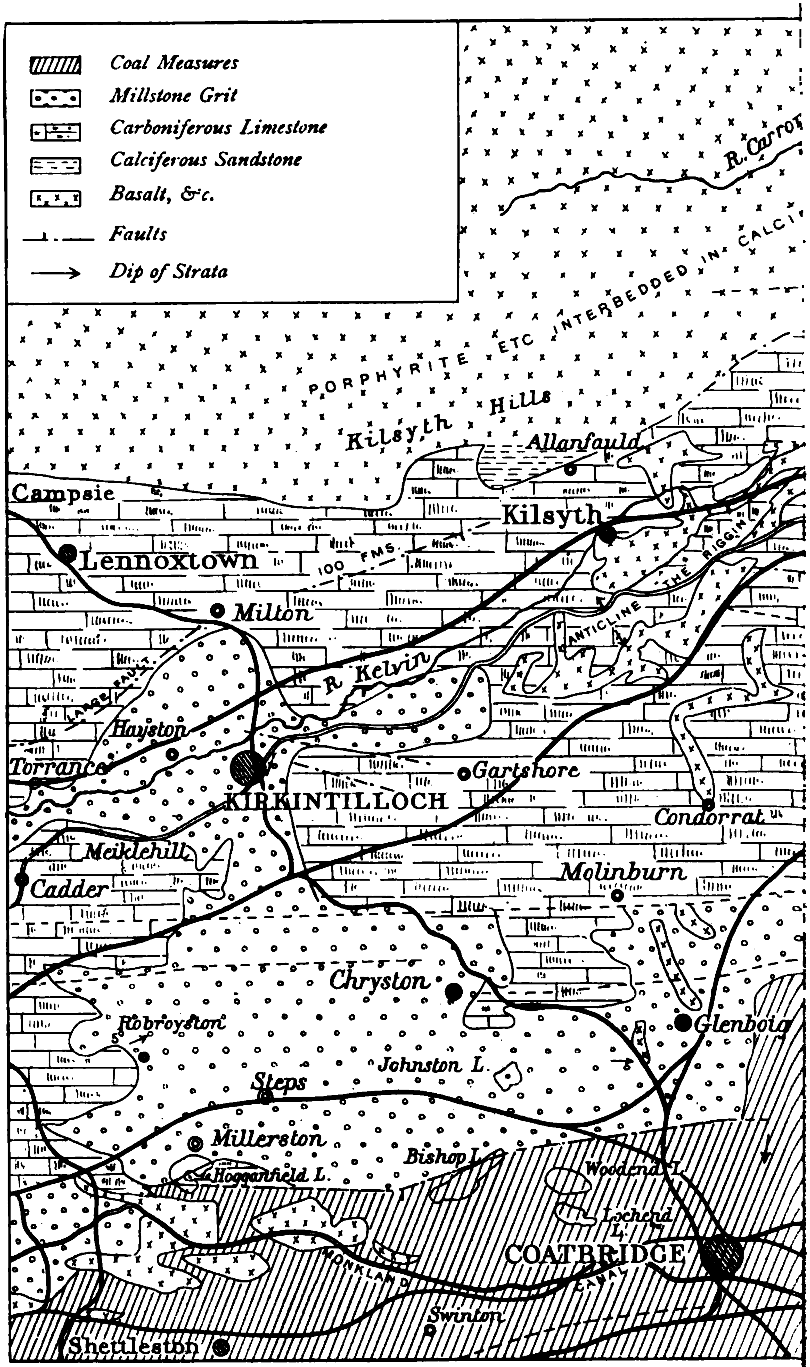
		Ft.	Ins.
Roof	Fireclay and Fakes		
	Gas Coal	0	2
	Ironstone Balls and Shale	1	6
Working	Gas Coal	0	3
	Black Shale	0	4
	Coal ... ... 2 ft. to	2	6

The 2 inches of gas coal in the roof is partly recovered from the brushing and from falls in the waste.

The Virtuewell Coal is being extensively opened up in the Larkhall and Stonehouse district, where the Upper Coals are now exhausted. It is there found from 1 foot 6 inches to 3 feet thick, and by the use of coal-cutting machinery it is being worked to a profit even when as thin as 18 inches. The shale and gas coal is sometimes represented in this district by a band of Wild coal from 6 inches to 1 foot thick, lying about a foot above the coal.

In the Shotts and Benhar coal-fields the Virtuewell Coal is known as the Benhar Coal.

GEOLOGICAL MAP



The Virtuewell Seam probably takes its name from the Virtue Well, a mineral spring found north-west of Airdrie, near which the seam crops out. The Kiltongue and Drumgray Coals also get their names from farms in the same locality, where they were first worked.

The Ladygrange Coal, a seam lying about 7 fathoms below the Virtuewell Coal, has only been developed in the eastern part of the county, at Arden and Shotts, and it is also worked in the Slamannan coal-field.

The Kiltongue Coal is generally a hard, splinty coal of second-class quality. It is somewhat variable in its thickness, and is frequently split up into two or more seams by bands of dirt. At Uddingston it has the following section:—

	Ft.	Ins.
Sandstone Roof		
Coal	1	0
Dirt	0	6
Coal	0	11
Dirt	1	10
Coal	2	10

The partings become thinner towards the north-east, and the section of the seam at Coatbridge is as follows:—

	Ft.	Ins.
Coal	1	1
Gas Coal	0	3
Coal	1	0
Blaes...	0	3
Coal	2	2
Fireclay	0	2
Coal	1	5

Going west, on the other hand, the partings become much thicker until it becomes necessary to work the coal as two separate seams. In the district north of Baillieston one of the portions of the seam has disappeared, and the remaining portion is 2 feet 6 inches to 2 feet 9 inches thick, and of rather better quality.

The Kiltongue Coal in the Coatbridge district is largely used for gas-making purposes. It yields over 10,000 cubic feet of gas per ton, with an illuminating power of from 19 to 20 candles. The coke is of very good quality, and amounts to 12 cwts. per ton.

In the upper leaf of the seam a band of cannel coal, about 3 inches thick, is sometimes found. This cannel coal is one of the richest in the country, yielding 15,000 cubic feet of gas, with an illuminating power of 40 candles. Unfortunately it is only found in a limited area, between Airdrie and Darngavil, and even there it is very erratic in its occurrence. It is now mostly worked out. At Calderbank an ironstone, about 9 inches thick, with which a gas and free coal is associated, takes the place of the Kiltongue Coal. It is known as the Calderbraes or Kennelburn Ironstone.

In the Larkhall district the Kiltongue Coal is now being extensively opened up. Its quality there is generally very good, as the following analysis from Swinehill Colliery shows:—

Volatile Matter	28.73	per cent.
Fixed Carbon	56.98	„
Ash	1.04	„
Sulphur	.33	„
Water	12.92	„

The coke from this seam gave the following analysis:—

Fixed Carbon	98.00	per cent.
Sulphur	.20	„
Ash	1.80	„

The Kiltongue Coal can generally be identified in boring by the occurrence of a Mussel-band Ironstone from 6 inches to 2 feet thick about 5 to 10 fathoms above the coal. This Mussel-band is remarkably persistent throughout all the Lanarkshire districts, although sometimes it occurs as a "foul" coal, and sometimes as a shale.

In the Stonehouse coal-field it was formerly worked to some extent on account of the oil which was obtained from the shale. The remains of the oil retorts can still be seen at Swinehill and Birkenshaw.

A seam of coal is sometimes found about 3 fathoms below the Kiltongue Coal, and is known by various local names. Near Airdrie a gas coal is sometimes associated with this seam, which goes by the name of the Drumbowie Gas Coal. The section of the working is as follows:—

	Ft.	Ins.
Blaes	2	6
Rough Coal	0	10
Shale	0	4
Hard Fireclay	1	0
Gas Coal	1	1
Hard Fireclay	2	6

At Glentore, in New Monkland parish, a seam was found in the same position, about 20 inches thick, and known there as the *Lime Coal.*

At Baillieston there is a seam, which has not been worked, lying 16 feet below the Kiltongue Coal. The section is:—

	Ft.	Ins.
Soft Coal	0	1½
Cannel Coal	0	1
Coal	1	6½

At New Swinton this seam is found 1 foot 2 inches thick. In the Larkhall district it has also been found in some bores about 1 foot to 14 inches thick. This also is a seam which may come to be worked at some future date when the thicker coals are exhausted.

The Upper Drumgray Coal, where found in the Clyde basin, is usually a hard blue-black coal, suitable for furnaces. In Slamannan district it is a first-class steam-coal, with a very small percentage of ash. It is there known as the Coxroad Coal. In Shotts district it goes under the name of the Furnace Coal. In Carluke district it is known as the Castlehill Second Seam.

Between the Upper and Lower Drumgrays a seam of coal is occasionally found, varying from 1 inch to 30 inches in thickness. It has been worked to a small extent in New Monkland parish, but is better developed in the Shotts and Benhar field, where it is known as the Shotts Low Coal.

The Lower Drumgray Coal is generally a softer coal than the Upper Drumgray, and is frequently of a better quality as a household coal. It is not so persistent as the Upper Drumgray. Although it takes its name from the upper seam it is not found at all at or near Drumgray. It corresponds with the Shotts Smithy Coal and the Slamannan Coxroad.

The seams between the Drumgray Coal and the Slatey-band Ironstone have only been developed in the eastern portions of the county at Shotts and Fauldhouse, and will be more conveniently dealt with when describing those fields.

In a paper read before the Philosophical Society of Glasgow[1], by Mr. W. Carrick Anderson, M.A., B.Sc., Assistant to the Professor of Chemistry, Glasgow University, the chemistry of the coals of the Clyde basin is dealt with, having special reference to the coking qualities of the various seams. In that paper Mr. Anderson points out that the Upper Coals from the Palacecraig Ironstone to the Airdrie Black-band Ironstone are not used for coking purposes in any part of the district. The Lower Coals he describes as semi-coking coals. The underlying coals in the Carboniferous Limestone series he describes as strongly-coking coals.

In the course of his paper Mr. Anderson gives the following analyses of some of the principal seams:—

TABLE I

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Hydrogen	4.52	4.98	4.82	5.54	5.10	5.06	5.14	5.20
Carbon	71.88	73.62	75.50	76.16	74.67	80.67	82.80	81.50
Oxygen	11.10	9.50	8.71	7.52	8.62	7.50	5.67	7.53
Nitrogen ...	1.53	1.54	1.50	1.52	1.54	1.84	1.89	2.04
Moisture	9.99	9.08	7.27	5.56	7.77	1.98	1.75	1.72
Ash	.98	1.28	2.20	3.70	2.30	2.95	2.75	2.01
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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[1] *Proceedings*, 1897–1898, vol. xxix, p. 72.

TABLE II
COMPOSITION OF ABOVE COALS CALCULATED ON DRIED SAMPLES

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Hydrogen ...	5.02	5.47	5.20	5.87	5.53	5.16	5.23	5.29
Carbon	79.87	80.97	81.42	80.63	80.97	82.30	84.28	82.93
Oxygen	12.33	10.45	9.39	7.97	9.34	7.65	5.77	7.66
Nitrogen ...	1.70	1.71	1.62	1.61	1.67	1.88	1.92	2.08
Ash	1.08	1.40	2.37	3.92	2.49	3.01	2.80	2.04
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE III. COMPOSITION OF THE DRY ASH-FREE COALS, CALCULATED FROM THE FOREGOING

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Hydrogen ...	5.07	5.56	5.32	6.11	5.67	5.32	5.38	5.40
Carbon	80.74	82.13	83.41	83.92	83.03	84.86	86.70	84.67
Oxygen	12.47	10.59	9.62	8.29	9.59	7.89	5.94	7.82
Nitrogen ...	1.72	1.72	1.65	1.68	1.71	1.93	1.98	2.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Combined[1] Hydrogen	1.56	1.32	1.20	1.04	1.20	.98	.74	.98
Disposable Hydrogen	3.51	4.24	4.12	5.07	4.47	4.34	4.64	4.42
Ratio $\frac{\text{Disposable H.}}{\text{1000 Carbon}}$	43.47	51.62	49.39	60.41	53.84	51.15	53.50	52.20

TABLE IV. PROXIMATE ANALYSES OF THE ABOVE SAMPLES

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Moisture	9.99	9.09	7.27	5.56	7.77	1.98	1.75	1.72
Ash	.98	1.28	2.20	3.70	2.30	2.95	2.75	2.01
Volatile Matter ...	33.33	35.84	36.22	38.25	33.53	32.55	27.40	28.45
Fixed Carbon ...	55.70	53.79	54.31	52.49	56.40	62.52	68.10	67.82
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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[1] These relations have been founded upon as affording a constant and well-marked distinction between coking and non-coking coals. It is true that *generally*, in coking coals, the percentage of, so-called, combined Hydrogen $\left(=\frac{\text{oxygen}}{8}\right)$ is lower than in non-coking; but it will be obvious, from a comparison of these figures with those in Tables IV and VI, that no reliance can be placed upon such data as an index to the degree of coking power, or even to the percentage yield of "fixed carbon".

TABLE V. SPECIFIC GRAVITIES AND CALORIFIC VALUES

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
Sp. Gravity ...	1.266	1.261	1.292	1.290	1.286	1.291	1.306	1.275
Calorific Value (Thompson's Calorimeter)	7480	7590	7425	7370	7480	7535	7865	7810

"For the purpose of obtaining a comparative estimate of the caking power of these coals I employed the simple test given by M. Louis Campredon, which consists in igniting one gramme of the coal with the largest quantity of fine white sand which it is capable of binding into a mass that just coheres. The weight of sand in grammes is the 'caking index'. Tested in this way the samples gave the following results:—

TABLE VI

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
Caking Index ...	4+	4	3·5	3·5−	4	9+	15·5	16+

"The last three are true caking coals, and are all used for the production of high-class foundry coke. In the crucible they give strongly-swollen, hard, metallic-looking 'cokes'. The Main and Ell Coals give slightly swollen coke residues in the crucible, while the residues from Splint, Gas, and Virgin are flat or slightly concave cakes of less bulk than the original coal. None of these is anywhere employed for coke-making."

The Slatey-band Ironstone is generally taken as the base of the Coal-measures in the western counties. It corresponds with the Black-band Ironstone of Lugar. There are frequently two ironstones, separated by 16 to 17 fathoms of strata, and the Main and Colinburn Coals of Bathgate occur between the two positions. The Upper Slatey-band was worked at Stepends and Loadmanford, in New Monkland parish, and is still being worked at Brownieside and Arden in the same parish. The ironstone that was worked at Castlehill, Carluke, is probably the same seam. The ironstone is very irregular in its occurrence, being sometimes only a few inches thick and then swelling out to several feet in a very short distance. It appears to have been laid down in irregular pools on the surface of the sandbanks of the Millstone Grit formation. The quality of the Slatey-band Ironstone is exceeedingly good, but the irregularity of the seam causes the working to be somewhat risky and expensive, and it requires to be very carefully proved by bores a short distance apart. It has not been found in the western district of Lanarkshire.

The following is an analysis of this seam:—

Protoxide of Iron	54.03	per cent.
Carbonic Acid	33.22	,,
Carbon	6.24	,,
Combined Water	2.36	,,
Phosphoric Acid	1.14	,,
Sulphide of Iron	0.57	,,
Lime	0.86	,,
Silica	1.05	,,
Magnesia	0.53	,,

This analysis shows 42 per cent of metallic iron.

The Second, or Under, Slatey-band Ironstone is even more irregular than the First. It is found only in the eastern districts, at Shotts and Benhar.

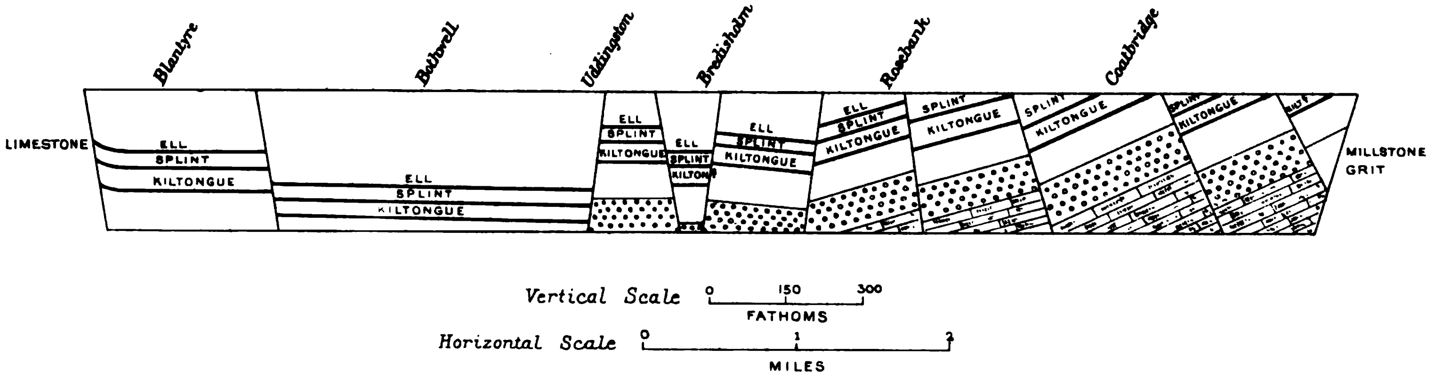
The general structure of the Clyde basin can be understood more readily by considering its relation to the whole of the Scottish central coal-field. That coal-field is found occupying an approximately triangular-shaped area in the counties of Lanark, Stirling, and Linlithgow. The apex of the triangle is at Govan, and the base stretches from about Stonehouse in Lanarkshire to Grangemouth on the River Forth. The triangular shape of the field results from two prevailing sets of dislocations which intersect one another at an angle of about 40 to 45 degrees, the one set running nearly east and west, and the other running from south-east to north-west. The northern boundary of the field is generally formed by the east-and-west faults, while the boundary from Govan to Stonehouse is formed by the south-east to north-west faults. Throughout the coal-field the principal lines of faulting are found parallel to those boundary faults. It thus happens that at many of the collieries the workings are divided by the faults into V-shaped areas, having the point of the V to the west. There are practically no important faults running north and south or north-east and south-west.

The majority of the east-and-west faults have an upthrow to the south, although there are notable exceptions to this rule. The intersecting series of faults on the other hand have, in the majority of cases, an upthrow to the south-west. The inclination of the strata is moderate, unless in the vicinity of troubles, with a general rise towards the north and north-east, so that the lower seams are found cropping out along the north-eastern margin of the coal-field.

The section fig. 3, Plate VIII, from Coatbridge to Blantyre, gives a fair idea of the structure of the basin. The seams dipping towards the south would soon attain a very great depth but for the fact that the successive faults bring them up again to the surface. It thus happens that the outcrop of the same seam of coal is found repeated several times, and a very large area is thus made available at a moderate depth. In the Hamilton coal-field the seams are found with a regularity practically unknown in any other part of Scotland. The absence of small faults or troubles, and the regular inclination of the seams, permits of the underground workings being laid off to the best advantage both for haulage and economical working of the coal. In most of the seams the roof is very good. Under these circumstances the proportion of coal lost in working is very small, and in this respect the Hamilton coal-field will compare favourably with any coal-field in Great Britain.

PLATE VIII

GENERAL SECTION OF THE CLYDESDALE COAL-FIELD FROM BLANTYRE TO COATBRIDGE



Along the south-west margin of the coal-field the seams have been tilted up by the great upthrow fault so that the inclination gradually increases from about 1 in 10 to 1 in 3, and close to the fault they become at places almost vertical.

On the geological maps published in 1872 the supposed positions of several large faults intersecting the Bothwell and Hamilton coal-field are indicated by dotted lines. These faults have since been proved by the colliery workings, and are found to correspond very well with the positions in which the Geological Survey has placed them.

Intrusive igneous rocks are practically unknown in the district from Govan to Hamilton, and along the valley of the Clyde to Dalserf.

Along the northern margin of the coal-field, from the east end of Glasgow to Airdrie, numerous intrusive sheets and dykes are found (see p. 93).

This intrusive zone continues eastward through Rawyards and Clarkston, and great masses of whin are spread out on the surface between Clarkston and Harthill, forming crags and hills which rise to a height of from 800 to 950 feet. The extension of these igneous rocks to the northward is discussed in the chapters dealing with the Slamannan and Falkirk coal-fields (see p. 158).

An important feature of this coal-field is the series of whin dykes or "gaws" which traverse the county from west to east. These dykes vary in thickness from a few feet up to 100 and 150 feet. They must be of a comparatively recent geological age, because they cut across all the rocks and are not displaced by any of the faults or dislocations. It is generally found that the seams are not displaced on either side of the whin dykes, the principal exception being the dyke which runs from Cadder through Molinburn and eastward to the Slamannan coal-field. That dyke occupies the line of a fault with an upthrow to north of about 70 to 90 fathoms. Those dykes should form natural barriers to regulate the flow of underground waters, but unfortunately they have been somewhat recklessly cut through in many of the underground workings. It has been observed in many places that the coal on either side of the dykes has been destroyed throughout a space equal to half the thickness of the whin.

Another form of trouble sometimes met with near the outcrops of the coal-seams is known as a "sand dyke". These "dykes" are only of superficial occurrence, and have been caused by water-courses of some recent geological period cutting deep troughs or valleys in the surface, and these have subsequently been filled up with sand and gravel.

At many of the collieries "wants" occur in the seams, where the coal has been washed away by aqueous action at the time of its formation. It is very frequently found that running parallel with the wants there is an equivalent area in which the seam has about double the thickness. One of the most remarkable of these wants has been traced in the Upper Coal Seam at Farm, Govan and Stonelaw Collieries for a distance of nearly 2 miles. It maintains a pretty uniform average breadth of about 165 feet, and on both sides the coal is of more than average thickness. None of the under seams were in the least affected by this want.

Professor James Geikie has given the following description of the cause of those "wants"[1].

"When one remembers the conditions under which our coal strata were accumulated, it is not hard to see why 'wants' should be common, and perhaps why the so-called 'doublings' should so frequently be associated with 'wants'. Our Coal-measures always suggest to me a great river with numerous effluents and affluents winding through interminable mud-flats. The flats covered with luxuriant vegetation, and interrupted here and there with creeks and lagoons. One can readily fancy how, during heavy floods, the large river with its effluents and affluents might undermine their banks, or overflow the flats, and cut new channels and courses through the jungles. It is possible to conceive also how, after unusually heavy rains, or a prolonged rainy season, the spongy vegetable soils, becoming surcharged, might burst and roll forward upon a comparatively slight slope. Or the under-soils upon an inclined surface might become so slippery with moisture as to cause a slide of the overlying jungle-growth and great club-moss trees. Again, one can conceive yet another way in which a coal-seam may appear to be doubled. Let us suppose a wide-spread marsh in which vegetation is more or less rapidly accreting. It is not unlikely that (owing to the irregular consolidation of the underlying sediments and buried soils and sub-soils), some portions of the marsh might become depressed below the general level for a few feet, and this depression would by and by be filled up by the continuous growth of vegetation creeping in, as it were, from all sides. Possibly the depression might at first be occupied by water—a shallow lagoon—in which fine carbonaceous mud might be deposited. Sooner or later, however, it would be filled up by vegetable growth, and thus we should have a thickening of one and the same coal-seam, with possibly thin partings of daugh, or coaly-blaes, dividing the thickened portion into two or three seams."

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[1] *Trans. Mining Inst. Scot.*, 1881, p. 256.

THE SHOTTS AND BENHAR DISTRICT.—As mentioned above (p. 106), a series of coal-seams is found in this district underlying the Drumgray Coals of the Clyde basin. Those coals appear to be mainly developed to the east of a large fault, with a down-throw to west, which runs about N. 20 W. from Bonkle, near Newmains, through the village of Salsburgh to near Plains, on the North British Railway. At Plains a bore was put down to the west of this fault for a distance of 66 fathoms below the Drumgray Coal. No coal-seams whatever were met with at that depth, and there is no evidence that there are any seams underlying the Drumgray Coals, in the western district of Lanarkshire.

The average section at Shotts and Dewshill is as follows:—

		Fms.	Ft.	Ins.
Coal		0	1	3
Strata		8	0	0
Craw Coal		0	1	4
Strata		3	2	0
Benhar Coal (Virtuewell)		0	3	6
Strata		7	0	0
Ladygrange Coal	0 to	0	1	0
Strata		11	0	0
Kiltongue Mussel-band		0	0	8
Strata		7	0	0
Kiltongue Coal	0 to	0	1	3
Strata		13	0	0
Shotts Furnace Coal (U. Drumgray)		0	2	6
Strata		6	3	0
Laigh Coal		0	1	6
Strata		7	0	0
Shotts Smithy Coal (L. Drumgray)		0	1	6
Strata		6	0	0
Shotts Gas Coal		0	2	9
Strata		8	0	0
Clefted Coal or Blackhall Parrot	1 ft. 3 ins. to	0	3	0
Strata		24	0	0
Liquo, Mill, or Crofthead Coal		0	1	9
Strata	about	16	0	0
Bowhousebog Coal		0	5	0
Strata	about	2	0	0
Upper Slatey-band Ironstone				
Strata	about	10	0	0
Lower Slatey-band Ironstone.				
Millstone Grit Series.				

In the district adjoining the North British Railway from Caldercruix to Westcraigs, the whinstone appears at the surface overlying the Drumgray Coal. The under seams appear to be rather thin in this section, but get thicker going eastward. They are being extensively worked at Westcraigs, and continue eastward into the county of Linlithgow, where they are worked in the Armadale coal-field.

In the following sections I have shown the seams as proven at Westrigg Colliery, with the corresponding seams as shown in a bore at Blairmuckhill, about a mile and a half west from that colliery. These sections illustrate the progressive thickening of the coal-seams going from west to east.

Section at Westrigg.					Thickness of corresponding seams at Blairmuckhill.	
		Fms.	Ft.	Ins.	Ft.	Ins.
Lower Drumgray Coal		0	1	10	1	0
Strata (with one or two seams under a foot thick)		12	2	0		
Coal, 10½ ins. Fireclay, 1½ ins. Coal, 5 ins.	Probably Clefted Coal	0	1	5	1	3
Strata		17	2	0		
Mill Coal		0	2	1	1	8
Strata		9	0	0		
Iron Balls, 6 ins. Dark Blaes, 4 ins. Coal, 2 ft. 3 ins. Dark Fireclay, 6 ins.	Ball Coal	0	3	7	3	0
Strata	9 ft. to	4	0	0		
Coal, 2 ft. 5 ins. Parting, 1 in. Coal, 1 ft.	Main Coal	0	3	6	1	4
Strata with a Mussel-band		13	2	0		
Colinburn Coal		0	2	4	1	8
Strata	2 ft. to	1	0	0		
Torbanehill Gas Coal and Ironstone position.						

The Torbanehill Coal is not found as a gas coal here, and there are no workings in this seam. The section is as follows:—

	Ft.	Ins.
Coal	0	11
Blaes	0	3
Coal	1	3
Fireclay	0	3
Ironstone Balls	0	8½
Blaes	2	0
Coal	0	8

The Lower Drumgray Coal shows occasionally some signs of burning, but not sufficient to make it unworkable. It has a good sandstone roof.

The Mill Coal, the Ball Coal, the Main Coal, and the Colinburn Coal are being worked, and are of fairly good quality.

The Ironstone balls above the Ball Coal are being worked along with the coal. They contain about 45 per cent of iron.

The Slatey-band Ironstones have not been found in the Westcraigs district, but they come in a little farther south at Harthill, and they have been extensively worked in the Shotts and Dykehead area. At Goodockhill, on the western side of the great fault above referred to, the Lower Slatey-band Ironstone was found as a very irregular seam, varying in thickness from 0 to 8 feet. Occasionally a thin seam of coal occupied the Ironstone position.

The Upper Slatey-band Ironstone is more irregular than the Lower, and has only been worked at one or two points. At Bowhousebog it was found about 1 foot thick.

A seam of Ironstone balls, 3 inches thick, occurs about 6 inches above the Upper Drumgray Coal, in the Shotts district, and has been largely worked along with the coal, and smelted at the Shotts Iron-works.

Throughout the whole of the district from Westcraigs to Shotts, the seams near the surface have suffered more or less from burning. In some cases they are very good steam coals, in others the coal is reduced to an anthracite, and in others it is rendered quite useless. As there is no whin underlying the coals, and as the under seams are less burnt than those above them, it is evident that this burning must have been caused by an overlying whin. There is ample evidence of the presence of this whin in the craigs at Westcraigs, and in the Moffat Hills at Caldercruix, and also at Cant Hills, Shotts, and many other places. Those high grounds are the remainders of a great sheet of whin that at one time spread over the whole district but has now been largely removed by denudation, and thus cut up into apparently isolated patches. As described (on p. 158), this sheet of whinstone has come up from below the Slamannan coal-field, and seems to have reached its limit at some point a little to the south of Shotts. The burning of the coals by a whin like this, which is above the seams, is apparently much more erratic than the burning in the Slamannan coal-field, where the whin is below the coal. At Cant Hill, near Kirk-of-Shotts, the Upper Drumgray, or Shotts furnace coal, is found as an anthracite.

DOUGLAS AND LESMAHAGOW COAL-FIELD.—The district described under this designation embraces a detached basin stretching from a little south of Lesmahagow to Douglas and Glespin. The area of the basin is about 14 square miles.

In this little coal-field the whole of the Carboniferous strata are represented from the Upper Red Sandstones to the Calciferous Sandstones. On every side these measures are surrounded by Old Red Sandstone rocks. At the end of the Old Red Sandstone period there were evidently great changes in the levels of the country, whereby the area on which the strata of that series had been deposited was elevated throughout the southern uplands of Scotland, and what is now the Scottish coal-field remained as a great inland sea, or lake, in which fresh-water and marine conditions alternated. The southern limits of this lake are indicated approximately by the boundaries of the Ayrshire, Douglas, and Lothian coal-fields.

From the southern mainland a peninsula appears to have stretched towards the point where Lesmahagow is now built, having a shape somewhat corresponding to the area of Old Red Sandstone shown on the map (Plate V). The Douglas coal-field was thus entirely cut off from the Lanarkshire coal-field, and the water in which it was deposited formed a bay connected with the Ayrshire Carboniferous sea, by way of Glenbuck and Muirkirk.

A study of the Calciferous Sandstone rocks shows that at the beginning of the Carboniferous period the bottom of that sea must have been very irregular, and the frequent overlaps point to considerable variations in the rate of subsidence. The greater part of the deep irregular hollows in the Old Red Sandstone rocks were filled up during the Calciferous Sandstone period, but some of them must have remained until later times.

If these suppositions regarding the geological structure of this basin are correct, we would expect that there was more affinity between the coal-seams of the Douglas basin and the Ayrshire basin than between the coal-seams of the Douglas basin and the Lanarkshire basin. This affinity and difference would naturally be more marked in the seams which were first deposited—*i.e.* those of the Carboniferous Limestone period—than in the more recent deposits of the Coal-measures period, because many of the local irregularities would be smoothed out before the later measures were deposited.

It will be observed from the following description of the coal-seams that this hypothesis is fully borne out.

The Coal-measures of the Douglas coal-field occupy an area of about 5 miles, stretching in a narrow strip along the valley of the Douglas Water, with a southern extension along the Kennox and Glespin Waters. The coals from this series have been worked for over 100 years in the vicinity of Glespin, and they have also been worked to a small extent in the glebe lands near Douglas village.

North-eastward from Douglas there is an area of one or two square miles still intact underneath the policies of Douglas Castle.

The Coal-measures of Douglas occur in the form of a trough about a mile wide, and surrounded on both sides by the Millstone Grit. On the glebe lands to the east of Douglas the coals were found dipping towards the centre of the trough at an angle of about 45 degrees, but flattening out towards the centre. On the west side the boundary is somewhat indefinite and the outcrop of the coal-seams has not yet been accurately traced.

The section of the seams found at Glespin is here given:—

	Fms.	Ft.	Ins.
Coal	0	1	3
Strata	0	2	0
Coal	0	1	6
Strata	24	4	0
Black-band Ironstone	0	0	4
Strata	10	0	0
Seven-foot Coal	1	1	0
Strata	11	0	0
Mussel-band Ironstone	0	0	6
Strata	1	1	0
Three-foot Coal (with stone)	1	0	6
Strata	10	0	0
Four-foot Coal (with parting)	0	4	9
Strata	12	0	0
Nine-foot Coal	1	3	0
Strata	7	0	0
Coal	0	1	2
Strata	2	0	0
Coal	0	2	7
Strata	7	2	0
Carmacoup Coal	0	4	0
Strata	5	0	0
Coal (with 4 ins. of cannel)	0	2	0
Strata	4	0	0
Mussel-band Ironstone	0	0	3
Strata	2	3	0
Supposed position of Slatey-band Ironstone at base of the Coal-measures.			
Strata ... about	15	0	0
Kennox Coal	0	4	6
Strata to Upper Limestone, probably about	75	0	0

The section to the Nine-foot Coal has been passed through by the shaft at Glespin Colliery, and a bore has been put down from the Nine-foot Coal to the Carmacoup Coal. Below the Carmacoup Coal has been compiled by observations of the outcrop.[1]

Glespin Colliery is situated towards the south-western extremity of the trough, and the seams are found cropping out south of the working pits. At the outcrop the inclination is about 1 in 3, but at the pits it has decreased to 1 in 5.

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[1] *Trans. Fed. Inst. Mining Engineers*, vol. xvi, p. 442.

A comparison of the foregoing section with the sections of Wellwood, Cumnock, and Dalmellington would lead to the conclusion that the Four-foot and Nine-foot Coals underlying the Mussel-band Ironstone correspond with the Five-foot and Six-foot Coals of Wellwood and with the Camlarg Coals of Dalmellington. If this is correct, then the Seven-foot Seam may correspond with the Virtuewell Coal of Lanarkshire. The Three-foot Coal would be the Kiltongue Coal, and the Four-foot and Nine-foot the Upper and Lower Drumgrays.

In that case the underlying seams must correspond with the Armadale Coals and the Melville Coals of Edinburghshire.

Bores have recently been put down to those lower seams near the outcrop in the lands of Carmacoup. A coal corresponding probably with the Carmacoup Coal in the above section has been proved over a considerable area, with a thickness varying from 3 feet 1 inch to 3 feet 10 inches There is a parting in the centre of the seam, but the coal is reported to be of very good quality, especially for gas-making purposes. The Caledonian Railway Company are at present constructing a branch railway from Inches station to develop this part of the coal-field, and it is expected that several new pits will be opened up on the completion of this branch line. Boring operations are also being conducted by Messrs. John Watson, Ltd., to prove the extension of the Coal-measures north-east of Glespin. No definite information is yet available regarding these bores, but, as far as I can learn, the results are somewhat disappointing.

The workings at Glespin Colliery have been principally in the Seven-foot and Nine-foot Seams, and these seams are now practically exhausted to the outcrop. They appear to have also been worked out along the outcrop for a considerable distance northward beyond Douglas village.

They were of very fine quality, equal to the best Lanarkshire Ell Coals, and found a ready market in the South of Scotland.

The Seven-foot Coal is composed of the following subdivisions:—

	Ft.	Ins.
Wild Coal	1	2
Blaes	0	2
Coal	7	3
Wild Coal	1	9

The Three-foot Coal has not been worked to any extent. It consists of 3 feet of coal, 2 feet of stone, and 1 foot 8 inches of bottom coal.

The Four-foot Coal is a workable seam containing 3 feet 6 inches to 4 feet 4 inches of coal in two bands, separated by about 6 inches of fireclay.

The other seams have not yet been worked.

A fault throwing up the Old Red Sandstones against the Upper Red measures terminates the workings of the Glespin coals to the north-west. A section of the strata beyond this fault is given in a paper by the late Mr. Robert Weir[1] (see Plate IV). Mr. Weir says:—

"At some period the Upper or Red measures may have conformably overlain the Coal-measures, and both groups of rocks in regular sequence seem to have overlapped the Old Red Sandstone. This would account for the absence of the Millstone Grit and Carboniferous Limestone. When the subsidence from the direction A to B took place, causing the tilting of the Upper or Red measures, it would leave the cavity now filled with clay. A mine was cut from C to D and passed through a succession of soft red and green clays which had the appearance at places of being regularly stratified; but they were probably washed down from the higher strata in the neighbourhood, to which their composition corresponds. At D the mine passed into a post of hard red sandstone, and, if the vertical displacement does not exceed the thickness of the Coal-measures, by continuing the mine they may be found resting directly on the Old Red Sandstone at the overlap."

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[1] *Trans. Fed. Inst. Mining Engineers*, vol. xvi, p. 444.

As shown on the map, Plate V, the CARBONIFEROUS LIMESTONE is found coming to the surface round the greater part of the Douglas and Glespin coal-field. Workings are being carried on extensively in the northern district at Bankend and Coalburn, and in the south-eastern district at Rigside and Ponfeigh. In the south-western district the Limestone measures are found cropping out in the Glespin Water and Kennox Water, and at present boring operations are being carried on to prove the coal-seams there. There is an area of Limestone measures between Ponfeigh and Coalburn, occupying the eastern end of the coal-field, in which no mining operations are at present being carried on. A comparison of the sections indicates that the coal-seams vary considerably in each of the districts. The Coalburn and Bankend Seams correspond very closely with the Glenbuck and Muirkirk sections, and are evidently a continuation of that coal-field. From the Index Limestone to the Lower or Macdonald Limestone the thickness of strata is there found to vary from 280 to 370 feet, containing from 37 feet to 24 feet of coal. At Ponfeigh the thickness of strata from the Index Limestone to the Macdonald Limestone is 1047 feet, containing 47 feet 3 inches of coal, and overlying that there are five seams between the Calmy, or Arden, and the Index Limestones containing 22 feet of coal.

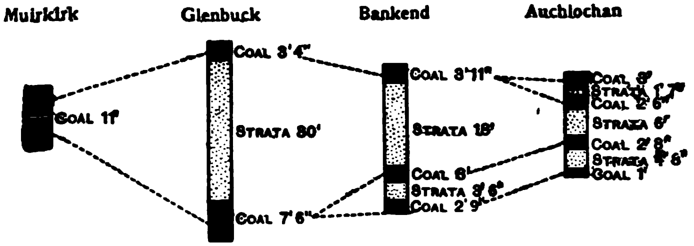
The extension of the coals across the basin from Ponfeigh to Bankend has not yet been traced, and it is impossible to correlate the seams on either side of the basin.

I think that it is evident that the shore line of the sea or lake in which the Carboniferous Limestones were originally deposited runs along the north-western margin of the field between Coalburn and Lesmahagow, and then swings round the north-eastern margin by Brokencross Muir, but towards the south it may have continued for a considerable distance beyond the present limits of the coal-field, towards the great Silurian fault which is shown on the map as running through Crawfordjohn. As mentioned when describing the New Cumnock coal-field, that fault must have been in existence as a bank or shore-line during Carboniferous times. The extensions of the Limestone measures in the Glespin Water approach within about a mile of this fault, and they there show evidence of shore conditions.

The centre of the basin may have been occupied by a deep hollow, which, during the oscillations of level, would seldom become sufficiently shallow to permit of the deposition of coal-seams. This hypothesis is to some extent borne out by the result of a bore which was put down to a depth of 213 fathoms, near to Douglas Railway Station. In that bore only a few very thin seams of coal were met with. Of course it may be that the bore was not deep enough to reach the coal-seams of the Limestone measures, and that is a question which can only be solved by future explorations. Another bore was put down at Crowhill, about 1½ mile west of the Douglas Station bore. Some limestone and coal-seams were met with at a depth of about 100 fathoms, but were not of workable thickness or quality.

It is important to notice the great change there is in the strata in passing across from Coalburn to Auchenheath. In the whole district, from Auchenheath north-westward to Stonehouse and East Kilbride, the Limestone measures are particularly barren of coal-seams. At Auchenheath the thickness from the Rough or Index Limestone to the Lower Limestone is 355 feet, practically the same as at Coalburn; but this thickness of strata only contains a few very thin seams of coal, including the famous Lesmahagow Gas Coal. From the edge of the Coalburn field to the edge of the Auchenheath field is only about 2 miles. It is evident that there must have been a remarkable change in the conditions under which the Carboniferous Limestone strata were deposited in the two districts, a circumstance which has already been noted when dealing with the Carboniferous Limestone formation of the Ayrshire coal-field (see p. 11).

An interesting indication of the changes which occur in the deposition of a coal-seam as it approaches nearer the old shore line can be observed in tracing the Muirkirk Seven-Foot Coal eastward by Glenbuck and Coalburn.



Sections showing alterations in the Seven-foot Coal between Muirkirk and Auchlochan

To illustrate this, the sections of the seam at four different points are here shown.

As the area in which the coal was being formed approached the shore it was more frequently invaded by sand and mud, so that the seam came to be separated by irregular bands of foreign material. These sections illustrate the difficulty in correlating the seams of various districts where there are no connected sections. But for the fact that the field has been proved over the whole distance by the underground workings it would be impossible to affirm that the four coal-seams found at Auchlochan correspond with the single seam found at Muirkirk.

The complete sections at Bankend and Auchlochan are here given:—

BANKEND SECTION

	Fms.	Ft.	Ins.
Index Limestone (known locally as the Seven-foot)	1	0	0
Strata	5	0	0
Gas Coal ... ... o to	0	0	8
Strata	4	0	0
Smithy Coal (Ell Coal)	0	3	0
Strata ... ... 1 ft. 6 ins to	6	0	0
Three-foot Coal (Dross Coal) ... 3 ft. to	0	4	0
Strata	3	0	0

			Fms.	Ft.	Ins.
Coal	2 ft. 6 ins.	Glenbuck Four-foot Coal	1	4	0
Fireclay	1 ft. 6 ins.				
Stone	4 ft. 0 ins.				
Coal	2 ft. 0 ins.				
Strata			4	0	0
Black-band Ironstone			0	0	6
Strata			0 to 2	0	0
Smithy Coal	0 ft. 6 ins.	This is the Nine-foot Coal of Glenbuck.	1	2	0
Fireclay	1 in. to 1 ft. 0 ins.				
Free Coal	0 ft. 5 ins.				
Splint Coal	1 ft. 4 ins.				
Gas Coal	0 ft. 8 ins.				
Coal	1 ft. 2 ins.				
Stone	0 ft. 5 ins.				
Dross Coal	0 ft. 10 ins.				
Stone	0 ft. 2 ins.				
Coal	1 ft. 6 ins.				
Strata			8	0	0
Clay-band Ironstone (Glenbuck High-band)			0	0	4
Strata			1	0	0
Clay-band Ironstone (Glenbuck Mid-band)			0	0	2½
Strata			3	0	0
Coal	1 ft. 6 ins.	Glenbuck Thirty-inch Coal	0	5	6
Blaes	3 ft. 0 ins.				
Coal	1 ft. 0 ins.				
Strata			6	0	0
Coal	1 ft. 0 ins. Not worked.	Glenbuck and Muirkirk Six-foot Coal.	0	5	10
Free Coal	0 ft. 5 ins.				
Stone	0 ft. 3 ins.				
Free Coal	0 ft. 10 ins.				
Stone	0 ft. 2 ins.				
Free Coal	0 ft. 3 ins.				
Splint Coal	0 ft. 9 ins.				
Gas Coal	0 ft. 6 ins.				
Free Coal	1 ft. 8 ins. Holing.				
Strata			10	0	0
Macdonald or Stinking Coal			0	5	0
Strata (containing position of Macdonald Ironstone)			7	0	0
Limestone	1 ft. 8 ins.	Macdonald Limestone	1	0	10
Blaes	3 ft. 6 ins.				
Limestone	1 ft. 8 ins.				

This is an average section of the whole district of Bankend, Coalburn, and Dalquhandy. About 1½ miles farther north the seams have undergone considerable alteration, as shown by the section of Auchlochan Colliery. The Index Limestone is found there at a depth of about 40 fathoms.

In the strata above the Index Lime there are several seams of limestone corresponding with the Gair or Cowglen Limestone and the Belston Burn Limestone of Carluke. There is only one thin coal-seam, above the Index Limestone.

Auchlochan Section

			Fms.	Ft.	Ins.
Index or Seven-foot Limestone			1	1	3
Strata			4	0	0
Foul Coal			0	1	0
Strata			7	0	0
Smithy Coal			0	2	8
Strata			0	1	7
Dross Coal		2 ft. 8 ins. to	0	4	2
Strata			1	0	0
Coal	2 ft. 7 ins.	Four-foot Coal (called locally the Ell Coal).	1	2	11
Fireclay 2 ft. to	4 ft. 6 ins.				
Coal	1 ft. 10 ins.				
Strata			2	0	0
Black-band Ironstone		0 to	0	0	7
Dross Coal	0 ft. 6 ins.	This is the Nine-foot Coal of Glenbuck.	2	0	3
Fireclay	0 ft. 3 ins.				
Splint Coal	1 ft. 3 ins.				
Gas Coal	0 ft. 5 ins.				
Splint Coal	1 ft. 0 ins.				
Strata	6 ft. 0 ins.				
Coal (not worked)	2 ft. 10 ins.				
Strata			6	0	0
Ironstone (High-band)			0	0	6½
Strata			3	0	0
Ironstone (Mid-band)			0	0	6
Strata			1	0	0
Coal (Glenbuck Thirty-inch)			0	0	8
Strata			4	0	0
Free Coal	1 ft. 4 ins.	Six-foot Coal	0	4	8
Stone	0 ft. 3 ins.				
Free Coal	0 ft. 9 ins.				
Stone	0 ft. 3 ins.				
Good Coal	0 ft. 10 ins.				
Gas Coal	0 ft. 5 ins.				
Free Coal	0 ft. 10 ins.				
Strata			1	0	0
Clay-band Ironstone (Low-band)			0	0	9
Macdonald or Stinking Coal			0	4	0
Strata			4	0	0
Macdonald Ironstone			0	0	5
Strata			7	0	0
Macdonald Limestone in four bands.					

Towards the north of Auchlochan the coal-seams become thinner and less valuable. At Auchren a small colliery is working a seam of good coal, supposed to be the Smithy Coal, at a depth of only 11 fathoms.

The section of all the coals has been proved by a bore on the same estate, a journal of which is given by Mr. J. M. Cairncross in a paper published in the *Transactions of the Institute of Mining Engineers*. In the following copy of that journal I have added the probable names of the various coal-seams:—

JOURNAL OF BORE NEAR AUCHREN

No.	Description of Strata.	Thickness of Strata.		Depth from Surface.	
		Ft.	Ins.	Ft.	Ins.
1.	Moss	13	0	13	0
2.	Gravel and Sand	33	0	46	0
3.	Sandstone	27	3	73	3
4.	Blaes	6	1	79	4
5.	Sandstone	2	3	81	7
6.	Sandstone, hard	4	9	86	4
7.	Fakes, dark	6	9	93	1
8.	Blaes	24	0	117	1
9.	Sandstone	2	9	119	10
10.	Blaes	4	3	124	1
11.	Coal (Smithy)	2	2	126	3
12.	Fireclay	1	7	127	10
13.	Coal, free (Three-foot)	2	0	129	10
14.	Fireclay	1	2	131	0
15.	Fakes	0	6	131	6
16.	Fakes	4	0	135	6
17.	Coal (Gas)	0	5	135	11
18.	Fakes	1	2	137	1
19.	Ironstone	0	6	137	7
20.	Shale	0	5	138	0
21.	Coal, free (Four-foot)	1	3	139	3
22.	Fakes ,,	4	7	143	10
23.	Coal ,,	0	8	144	6
24.	Fakes	22	9	167	3
25.	Coal, free (Nine-foot)	2	1	169	4
26.	Fakes ,,	5	11	175	3
27.	Coal, free ,,	2	0	177	3
28.	Sandstone	12	4	189	7
29.	Fakes and Fireclay	2	0	191	7
30.	Sandstone	1	0	192	7
31.	Fakes and Fireclay	3	6	196	1
32.	Sandstone	7	0	203	1

No.	Description of Strata.	Thickness of Strata. Ft.	Thickness of Strata. Ins.	Depth from Surface. Ft.	Depth from Surface. Ins.
33.	Fakes	9	0	212	1
34.	Blaes	4	6	216	7
35.	Ironstone (High-band)	3	0	219	7
36.	Blaes	0	6	220	1
37.	Ironstone (Mid-band)	0	4	220	5
38.	Blaes	2	0	222	5
39.	Sandstone	4	8	227	1
40.	Fakes and Blaes	13	9	240	10
41.	Coal, soft (Thirty-inch)	1	0	241	10
42.	Fakes	0	6	242	4
43.	Sandstone	2	9	245	1
44.	Fakes	1	6	246	7
45.	Blaes, dark	4	0	250	7
46.	Coal, free (Six-foot)	3	8	254	3

The coal-seams of the Coalburn district are generally somewhat inferior in quality, but many of them contain bands of gas coal which add very much to their commercial value. The common coals are largely used as locomotive coals by the Caledonian Railway Company, and they are also sold for steam-raising and bunker purposes.

The Nine-Foot and Six-Foot Seams are principally sold for gas-making purposes. As shown by the foregoing sections, both of these seams contain bands of gas or cannel coal. Although this cannel coal is of a very high quality it is generally found more profitable to deal with the whole of the seam as one subject, without separating the gas coal.

An analysis of the cannel coal from the Auchlochan Six-foot Seam, made by Mr. George R. Hislop, F.C.S., Paisley, in 1890, showed, on chemical analysis:

Volatile Matters (containing .57 of Sulphur)		43.57 per cent.
Coke	Carbon 36.87 Sulphur .24 Ash 16.22	53.33 ,,
Water expelled at 212° Fahr.		3.10 ,,
		100.00 ,,

"The practical results were 12,716 cubic feet of gas per ton, with an illuminating power of 32.43 candles. Value of gas from one ton of coal in sperm, 1413.87 pounds. Tar per ton of coal 23.75 gallons, and ammoniacal liquor per ton of coal 12.80 gallons."

"The mineralogical characters were: Colour, brownish-black with moderate lustre and brown streak; fracture, rather coarse and irregular, with impressions of stigmaria; cross-fracture, semi-conchoidal and angular, and exhibiting laminæ of bituminous coal and slight deposits of ferric bisulphide in the natural partings; compact and cohesive; on the fire it partially and slightly intumesces; colour of ash, pale pinkish brown; thickness of seam, 5½ to 6 inches and well defined; mean specific gravity, 1260 (water, 1000)."

"Remarks: This coal yields a large amount of illuminating matter per ton, and contains a small percentage of water with about the average amount of sulphur. The coal, however, is of little value as a fuel. Compared with Main Lesmahagow Cannel Coal, represented as 100, calculated on a basis of a production of 13,000 cubic feet of gas and 1535.5 pounds of sperm per ton, and having regard also to the secondary products and the cost of the purification of the gas, this coal is equal to 86.40."

The Macdonald Coal has not been worked yet, but it is supposed to be of a somewhat better quality here than it is in the Muirkirk district, and may come to be worked after all the better seams are exhausted.

I quote the following description of the Ironstones and Limestones from Mr. Cairncross' paper:—

"Until the opening of the Caledonian railway, in 1857, the total quantity of coal extracted must necessarily have been very small, as the ironstone was the great magnet that opened up the coal-fields in these days.

"Both the Clay-band and the Black-band Ironstones have been found and worked in the south of the field, especially in the Bankend and Auchlochan estates. For many years after the discovery and exploiting of the Clay-band Ironstone the Black-band Ironstone was believed to be absent.

"Some fifty-four years ago, however, this famous and well-known stone was also discovered in the district, by Mr. Wm. Forrest, of Brockley Farm, for many years a contractor under The Monkland Iron and Steel Company.

"The discovery of the Black-band Ironstone was made through an extensive fall taking place in the Clay-band Seam, which exposed another bed of ironstone higher up, which, on investigation, proved to be the famous Black-band Ironstone.

"It averaged about 7 inches in thickness, was of splendid quality, and had a rib of coal which varied from 4 to 5 inches thick immediately above it, which helped to burn the stone.

"The total quantity of ironstone despatched from this locality between January, 1857, and January, 1863, amounted to 80,000 tons, or upwards of 13,000 tons annually.

"No ironstone, however, is at present being worked in this field owing to the fact that it cannot be produced at a price sufficiently low to enable it to compete with foreign ore; indeed, it is very doubtful if any will ever be worked in future, as the Nine-foot workings immediately below will in all probability have ruined the stone.

"The Mountain Limestone or Productus Limestone has been wrought for many years at the northern end of the field, and was also formerly worked at Bankend, where it varies from 30 to 50 feet in thickness. This limestone is of great importance and interest to the geologist, being the lowest important recognizable strata of the Carboniferous Limestone series. It is of great extent and value, and by analysis has been ascertained to contain:—

Carbonate of Lime	94.40
Carbonate of Iron	2.22
Phosphates	0.58
Organic Matter	0.60
Silica	2.20
Magnesia	a trace.

The limestone is also known as the Main or Hawthorn Limestone.

"*Index Limestone.*—The Index or Seven-foot Limestone is at present only worked by the Poneil Coal Company, near Coalburn Station, though it was worked previously for many years at Auchinbegg, farther to the west of the field. It is of the following section, of good quality, and sold largely for building, gas-purifying, and agricultural purposes.

		Ft.	Ins.
Roof:	Blaes	—	
	Limestone	1	0
Worked:	Limestone	5	6
Holing:	Daugh	2	0

"In the section, 1 foot of limestone is left for the protection of the roof, the holing or under-cutting being done in the 2 feet of daugh."

As already mentioned, the Limestone measures are much thicker, and contain a greater thickness of coal, on the eastern side of the basin at Ponfeigh and Rigside than they do at Coalburn. The coal-seams in the Ponfeigh district crop out at an inclination of about 45° rising to the east. The outcrops occur on the hillside, and the facility with which the coals could be worked by day mines led to the exploitation of the district at an early period, before steam power was available. The result of that circumstance is that all the seams have been exhausted along the outcrops, and during the last few years deep pits have been sunk to reach the coals towards the centre of the basin. It has been found that the coals become thinner towards the dip. This is well illustrated by the following sections of the Big Drum Coal:—

SECTIONS OF BIG DRUM COAL

At Outcrop.	Ft.	Ins.	In Dip Workings.	Ft.	Ins.
Free Coal	7	0	Free Coal	4	6
Cannel Coal	2	6	Cannel Coal	0	4
Ironstone	1	2	Ironstone	0	0

The quality of the coals is somewhat similar to those found at Coalburn, and they are largely used for locomotive and manufacturing purposes. Nearly every seam contains bands of cannel coal of very good qualtity, and this, of course, makes a great difference in the commercial value of the subject. An average analysis of these cannel coals shows 12,000 cubic feet of gas of 29.34 candle power and 1170 pounds of coke per ton. The seam above the Index Limestone marked Gas Coal Seam in the undernoted section is of exceptionally high quality, the outcome in commercial practice being 11,732 cubic feet of gas of 35.31 candle-power per ton.[1]

The Ironstone associated with the Big Drum Coal has been worked to a limited extent, but it is not of much value.

There is also a band of ironstone below the Skaterough Coal, and it also is of little value.

The following is a general section of the Ponfeigh Coals, as found near the outcrop:—

	Fms.	Ft.	Ins.
Gill or Calmy Limestone	0	3	11
Strata	2	4	0
Gill Coal	1	1	2
Strata	23	5	0
Limestone Gas Coal	0	2	2
Strata	0	4	5
Coal 2 ft. 5 ins. **Cannel** 1 ft. 8 ins. **Stone** 0 ft. 6 ins. **Coal** 1 ft. 6 ins. } **Gas Coal Seam**	1	0	1
Strata	16	2	0
Limestone	0	4	0
Strata	6	2	0
Coal (foul)	0	3	0
Strata	10	1	0
Ellenora Coal	0	4	0
Strata	7	5	0
Limestone	0	2	0
Strata	10	2	0
Index or Smallburn Limestone	0	5	0
Strata	11	2	0
Nameless Coal	0	3	0
Strata	13	3	0
Wee Drum Coal	0	4	0
Strata	1	0	0
Big Drum Coal	1	3	6

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[1] *Trans. Inst. Min. Engineers*, vol. xvi, p. 441.

	Fms.	Ft.	Ins.
Ironstone	0	1	2
Strata	3	2	0
Skaterough Coal	0	4	9
Strata	6	0	0
Kirkroad Coal	0	5	0
Strata	5	0	0
Stony Coal	0	4	6
Strata	18	1	0
Back Coal	1	3	0
Strata	8	4	0
Rob Coal	0	4	0
Strata	3	0	0
Fallowhill Coal	0	4	0
Strata	60	5	0
Wood Coal	0	2	0
Strata	32	3	0
M'Donald Limestone	0	3	0
Strata	0	2	0
Coal	0	2	0
Strata	11	4	0
Ponfeigh Limestone (Hurlet)	1	3	0
Strata	16	4	0
Wee Limestone	0	3	0

The difference between this section and those of Coalburn and Auchlochan, previously given, would lead one to suppose that the seams were laid down in separate basins, and, although on the whole contemporaneous, were subject to entirely different local conditions.

On Brokencross Muir, along the northern boundary of the Douglas coal-field, several bores have been put down, but not to a sufficient depth to prove satisfactorily the nature and thickness of the coal-seams.

Some coals were worked 60 or 80 years ago near the Star Inn (Newfield Inn on Ordnance Survey maps). An old bore at that point shows the following section:—

	Fms.	Ft.	Ins.
Strata	3	1	0
Limestone	1	1	0
Strata	5	1	0
Coal	0	1	2
Strata	8	4	3
Limestone, in four bands (probably Index)	1	0	0
Strata	3	2	0

	Fms.	Ft.	Ins.
Coal	0	0	5
Strata	8	3	0
Ironstone	0	0	7
Strata	1	0	0
Black-band Ironstone	0	0	7
Strata	1	1	0
Coal	0	2	5
Strata	1	0	0
Coal	0	3	11
	35	4	4

The 3 feet 11 inches of coal at the bottom of this section appears to be the Three-foot (Dross Coal) of Coalburn. As far as I am aware no bores have been put down below this position, but it seems reasonable to suppose that the other coals of the Coalburn section will be found underneath.

THE CARBONIFEROUS LIMESTONE SERIES is found in Lanarkshire on both sides of the Coal-measures basin. On the southern margin the coals of that formation have been worked at Wilsontown, Climpy, Carluke, and Auchenheath. From Auchenheath to East Kilbride the Carboniferous Limestone measures have been well developed, but contain few workable coal-seams. On the northern edge the Limestone measures appear at Maryhill, Possil, and Bishopbriggs, and continue thence into the Kirkintilloch and Kilsyth coal-field.

THE POSSIL COAL-FIELD embraces the area stretching from Maryhill through the northern part of Glasgow to Cadder and Bishopbriggs, and northward to the county boundary near Lenzie. Both coal and ironstone have been very extensively worked throughout this area, and a considerable part of Glasgow is built on the old workings. Occasionally these workings have given unwelcome evidence of their presence when the underground water has been tapped by railway cuttings or similar operations.

There is still a good deal of coal lying intact throughout the western portion of Glasgow, but as the area has now been completely covered with buildings the coal must remain in as a support.

The following is a generalized section of the seams found at Springburn, Bishopbriggs, and Robroyston, and it may be compared with the typical section of the Possil Coals given on p. 146.

Section of Strata at Springburn, &c.

	Fms.	Ft.	Ins.
Limestone (Arden or Robroyston) ...	0	4	6
Coal	0	2	4
Strata	44	0	0
Limestone	0	1	10
Strata	4	1	0
Coal	0	1	2
Strata	22	5	0
Limestone	0	1	10
Strata	9	2	0
Limestone (Index)	0	2	0
Strata	18		0
Coal	0	1	6
Strata	12	0	0
Coal 2 ft. 10 ins. Fireclay 2 ft. 0 ins. Coal 1 ft. 8 ins. } Possil Upper Coal...	0	5	0
Strata	3	0	0
Possil Upper Ironstone	0	3	0
Strata, with two thin coal-seams ...	11	0	0
Possil Main Coal	0	2	0
Strata	2	3	0
Possil Lower Ironstone, with foul coal ...	0	1	3
Strata	2	0	0
Stone Coal	0	1	10
Strata	6	0	0
Coal (Shale or Skaterig)	0	2	0
Strata	6	0	0
Coal (Jordanhill Black-band Ironstone and Knightswood Gas Coal position) ...	0	2	0
Strata, with alternate layers of Clay-band Ironstone, including position of California Clay-band Ironstone	20	0	0
Upper Garscadden Black-band Ironstone	0	1	0
Strata to Hurlet Coal probably about	40	0	0

The principal working in this section has been in the Possil Upper Ironstone. Throughout the shallower parts of the district that seam has been practically exhausted, but large areas remain unproven and unworked to the dip at Hogganfield and Robroyston.

The section of the working at Balornock, near Springburn, was as follows:—

SECTION OF POSSIL UPPER IRONSTONE

	Ft.	Ins.
Clay-band Ironstone	0	3
Blaes and impure Gas Coal	1	0
Black-band Ironstone...	0	4½
Coal	1	5
	3	0½

The only one of the coal-seams which has been worked to any serious extent is the Main Coal. That coal is of fairly good quality for house purposes.

At Lumloch Colliery a gas coal above the Cowglen Limestone was worked, but it was of inferior quality. There was also an ironstone called "The Batchy" a few fathoms above the Possil Upper Ironstone.

At Garscube, to the west of Glasgow, the gas coal has been wrought out. The section of the seam was:—

	Ft.	Ins.
Coal	0	5
Foul Gas Coal	0	2
Gas Coal	0	7½
Coal	1	1
	2	3½

An attempt was made some years ago to work the Stone Coal and Skaterig Coal on the Garscube estate, near Maryhill, but the quality was very poor.

THE WILSONTOWN AND CLIMPY COAL-FIELD is a continuation of the Linlithgowshire coal-field described in Chap. VIII, and the strata found there form a connecting-link between the coal-fields of Lanarkshire and Linlithgowshire.

A general section of the seams is as follows:—

		Fms.	Ft.	Ins.
Climpy Gas Coal (inferior)		0	1	0
Strata		4	0	0
Climpy Limestone		0	4	6
Strata		28	0	0
Fireclay Craw Coal (Woodmuir Main Coal or China Coal of Foulshiels)		0	2	0
Strata		2	3	0
Craw Coal (Smithy of Woodmuir)		0	3	0
Strata		8	0	0
Coal (Lady Morton of Woodmuir)		0	2	6
Strata		1	0	0
Wilsontown Main Coal		0	4	6
Strata		15	0	0
Hogg Fence Ironstones		0	1	4
Strata		11	0	0
Wilsontown Gas Coal	9 inches to	0	1	10

The Gas Coal seam has been very extensively worked at Haywood, Wilsontown, and Climpy Collieries. The thickness is variable, and it appears to die out altogether before passing into Linlithgowshire. The following sections give a fair idea of the nature of the seam:—

Section of Gas Coal Seam at Wilsontown (No. 1).

	Ft.	Ins.
Free Coal	1	7
Gas Coal	0	3½
Coal	0	8
Pyrites	0	2
Coal	0	11
	3	7½

Section of Gas Coal Seam at Wilsontown (No. 2).

	Ft.	Ins.
Coal	0	3½
Gas Coal	0	7
	0	10½

Section of Gas Coal Seam at Haywood.

	Ft.	Ins.
Gas Coal	1	10
Ironstone	0	3
Coal	0	4
	2	5

An analysis of the Haywood gas coal, made by Mr. George R. Hislop of Paisley in 1889, gave the following results:—

COLOUR—Brownish-black with moderate lustre and yellowish-brown streak. Specific gravity, 1.235.

CHEMICAL ANALYSIS

Volatile Matters (containing .52 of sulphur)			43.73 per cent.
Coke, consisting of	Carbon	46.61	52.77 „
	Sulphur	.34	
	Ash	5.82	
Water expelled at 212° Fahr.			3.50 „

PRACTICAL RESULTS

Gaseous Products

Gas per ton of coal at 60° Fahr. and 30 inch Bar.	12,757 cubic feet.
Illuminating power of gas in standard candles	31.20 candles.
Value of gas from one ton of coal in sperm	1364.63 pounds.

Liquid Products

Tar per ton of coal	25.20 gallons.
Ammoniacal liquor per ton of coal	14.23 ,,
Strength of ammoniacal liquor	4.00 deg. Twadd.

Solid Products

Coke per ton of coal	1182.04 pounds.
Carbon in the coke	88.80 per cent.
Ash in the coke	11.20 ,,

"Compared with Main Lesmahagow gas coal, represented by 100 (calculated on the basis of a production of 13,000 cubic feet of gas and 1535.5 lbs. of sperm per ton, and having regard also to the value of the secondary products and the cost of purification of the gas), this coal is equal to 93.61."

The Main Coal and the Craw Coal are also being worked. In both of those seams there is a rib of stone running through about the centre of the seam.

A clay-band ironstone, occupying a position below the gas coal, has been worked on a small scale along the outcrops. Another ironstone seam has also been found below the Main or Hurlet Limestone, and it was formerly worked at the outcrop on the south-eastern edge of the coal-field.

The productive coal-bearing strata of the Climpy and Wilsontown coal-field are cut off to the south by a large east-and-west fault, which passes through the village of Forth and continues westward beyond the village of Carluke.

THE CARLUKE COAL-FIELD occurs on the southern side of this fault.

The section of the strata found at Carluke is as follows:—

	Fms.	Ft.	Ins.
Gair Limestone	0	4	6
Strata	20	0	0
Gillfoot or Belston Burn Limestone ...	0	4	0
Strata	24	0	0
Belston Limestone	0	4	0
Strata	4	3	7
Dross Coal (Catcraig)	0	2	0
Strata	4	4	2
First Carluke Coal	0	2	2
Strata	2	0	0
Second Carluke Coal	0	2	6
Strata	8	0	0
Tower Coal	0	2	4
Strata (with Seams of Ironstone) ...	12	0	0
Gas Coal (Lesmahagow position)... ...	0	0	9
Dross Coal	0	0	3
Lower group of Limestones, with local beds of Clay-band Ironstone			

The Lesmahagow Gas Coal has been worked to a very limited extent in the Carluke district, but it is generally thin and unworkable.

The Tower Coal is probably the same seam as the Wilsontown Main Coal, but it is not of such good quality.

The First and Second Carluke Coals were of better quality, and are now about exhausted.

The Catcraig Coal is a local deposit, which has only been worked to a small extent.

Among the lower group of limestones a Clay-band Ironstone, known as the "Raesgill Ironstone", was formerly worked.

Passing westward from the Carluke Coal-field there is a considerable alteration in the nature of the strata. Some of the coal-seams die out, but the Lesmahagow Gas Coal seam becomes thicker and of better quality. The analysis of this seam shows 11,830 cubic feet of gas per ton, with an illuminating power of 35.25 candles. At Crossford, Fence, and Auchenheath this gas coal has been worked out, and the pits are now being reopened to work some of the common coals.

The section of the various seams found in this part of the coal-field is here given:—

Section of Auchenheath Coal-Field

	Fms.	Ft.	Ins.
Gair Limestone	0	4	2
Strata	13	4	0
Belston Burn Limestone	0	3	3
Strata	23	0	0
Rough or Index Limestone	1	0	6
Strata	16	0	0
Smithy Coal (Catcraig)	0	1	4
Shelly Clay ,,	0	1	6
Coal ,,	0	4	0
Strata	2	3	0
Gas Coal (Wee Gas)	0	0	10
Black-band Ironstone	0	0	5
Shale, with Ironstone Balls	0	3	8
Coal	0	0	8
Fireclay	0	1	6
Dross Coal	0	3	0
Strata	9	0	6
Coal	0	0	10
Shale	0	5	0
Lesmahagow Gas Coal	0	1	9
Ironstone	0	0	4
Fireclay	0	1	3
Coal	0	0	6
Strata	24	0	0
Lingula or Calmy Limestone	0	2	3
Strata	0	1	2
Limestone (First Kingshaw)	0	1	6
Strata	3	2	0
Limestone (Second Kingshaw)	0	2	4
Strata, with Clay Ironstones	4	3	0
Limestone or Thin Coal (Main or Hurlet)	0	5	3

In the district from West Quarter to East Kilbride there is a stretch of Carboniferous Limestone measures forming a continuation of the Auchenheath coal-field. Diligent search has been made throughout this district for the Lesmahagow Gas Coal, but evidently that seam does not extend westward beyond Blackwood and Kirkmuirhill.

Some thin coal and ironstone seams have been worked in the Carboniferous Limestone series in the parish of

East Kilbride. A general section of the district, compiled from the journals of several bores and shafts, is as follows:—

	Fms.	Ft.	Ins.
Limestone (Limekilnburn = Gair)	0	4	6
Strata	15	1	4
Limestone	0	2	8
Strata	27	5	4
Limestone	1	0	0
Strata	15 fms. to 30	0	0
Crutherland House Coal	0	1	8
Strata	0	3	6
Crutherland Joint Coal	0	2	0
Strata	2	3	0
Crutherland Smithy Coal	0	1	3
Strata	about 30	0	0
Lime and Cement Stones			
Strata	about 25	0	0
Crossbasket Ironstones			

At Maxwellton, about 1 mile east from East Kilbride two seams of coal were recently being worked. They were each 1 foot 8 inches thick, and were separated by 3 feet of fireclay. The upper seam was of fairly good quality, but the lower contained a high percentage of ash.

The following is a section of the strata sunk through at Torrance Colliery, about 1½ mile south-east from East Kilbride:—

	Fms.	Ft.	Ins.
Surface Clay and Stones	2	1	0
Sandstone	0	4	0
Blaes, &c.	12	0	0
Coal	0	1	3
Fireclay	2	3	0
Rock	4	3	0
Coal	0	0	10
Dirt	0	4	0
Coal	0	0	8
Blaes	3	2	0
Limestone.			

The coal, 1 foot 3 inches thick, was being worked during the recent "boom".

At Crossbasket there were three seams of clay-band ironstone, varying in thickness from 6 inches to 9 inches. A pit to work these ironstones was put down by William Dixon and Company in 1853, and the area was exhausted. Some clay-band ironstones, occupying a position apparently about 20 fathoms below the Crossbasket Ironstones, were worked about twenty years ago by Messrs. Colin Dunlop & Co., of Clyde Ironworks, but there have been no recent attempts to work ironstone in this district.

Some indications of the probable condition of the coal-seams of the Carboniferous Limestone series in the area of the Clyde basin covered by the Coal-measures may be gathered from the workings around the fringe of the basin. The estimates of the coal still to work in this area, as given in a future chapter, are based on a consideration of these circumstances along with the conditions briefly outlined on p. 11.

At Auchenheath the workings in the Gas Coal seam were carried on underneath the Drumgray Coal, but, with this exception, no attempt has yet been made to open up these lower seams. An important bore-hole is, however, being put down by Messrs. James Nimmo & Co., Ltd., at Gartsherrie, passing through the Coal-measures and the Millstone Grit and penetrating the underlying Carboniferous Limestone series. The details of this bore are not available at the time of writing, but further particulars may be given in an appendix.

CHAPTER VI

Dumbartonshire

KIRKINTILLOCH AND KILSYTH.—The Kirkintilloch and Kilsyth coal-field, which lies mostly in the detached portion of Dumbartonshire, presents more evidences of geological disturbance than any other coal-field in Scotland. As shown in another chapter (see p. 14), the Limestone measures were deposited here under conditions of great irregularity. It thus happens that very few of the seams of coal and ironstone, or the intervening beds of shale and sandstone, maintain a constant thickness over any considerable area. The coal-seams fluctuate in thickness, and occasionally die out altogether in a way which adds very much to the uncertainty and cost of mining. Many local seams of coal are also found existing only throughout small areas.

The coal-field is traversed by many faults, some of them with a displacement of over 100 fathoms, and there are also numerous intrusive rocks burning the coal over considerable areas. The inclination of the strata varies greatly, at some places dipping steeply to the south, at others nearly level, and at others dipping towards the north.

The surface of the country also presents many evidences of geological fluctuations. The northern boundary of the coal-field is formed by a large fault, or rather series of faults, whereby the lowest beds of the Calciferous Sandstone period are brought to the surface in contact with the Carboniferous Limestone beds. The rocks of the Calciferous Sandstone series consist to a great extent of hard lavas and porphyrites, and these rocks have not suffered from denudation to the same extent as the softer rocks of the Carboniferous Limestone series. The result is that they have been left standing as a prominent range of hills, with an elevation of 1300 feet above the valley.

It can hardly be doubted that the Campsie valley owes its origin mainly to denudation, having evidently been scooped out by powerful ocean currents, which have washed away hundreds of feet of the softer strata. At Lennoxtown the valley is only about 1 mile wide at a level of 250 feet above the sea. On the north side of the valley the hills, which have been protected by the covering of basalt, rise to a height of over 1600 feet, and on the south side there is a hill, composed of Carboniferous Limestone rocks, which attains a height of about 600 feet. The stratification is nearly horizontal, and the same seams of coal and limestone are seen cropping out abruptly on both sides of the valley. These seams must have extended originally right across the valley before they were cut through by the denuding agents. The South Hill has been mined from both sides, and the same beds are found to pass right through it lying almost horizontal.[1] Considering all the adverse circumstances here met with, it might appear that the coal-seams of this field could hardly be worked to a profit. That, however, is very far from being the case. A very large amount of capital has been employed in developing the field, and some of the finest-equipped collieries in Scotland are to be found in this district. For instance, at St. Flannans, near Kilsyth, Messrs. Wm. Baird & Co. are sinking two pits which are being fitted up so that they may ultimately be sunk to a depth of 350 fathoms—a depth which has not yet been reached by any other pits in Scotland. The principal inducement to work the coals in this field is the fact that many of the seams have the property of coking, and the coke produced is of very high quality. At one time the ironstone seams were also in demand, but these are not now of much importance.

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[1] For further details of this interesting subject, see "Geology of the Campsie District", by John Young, LLD., F.G.S., *Transactions of the Geological Society of Glasgow*.

The Banton and Kilsyth coal-fields consist of a series of small detached basins or troughs in the Carboniferous Limestone series, the seams of coal and limestone being constantly repeated. Such a succession of basins implies a corresponding number of saddles, or domes. Of these the most noteworthy in the district is one which stretches through the Kirkintilloch and Kilsyth coal-fields for a distance of several miles. On either side of that anticline the strata have been tilted up at a high angle, and from the resemblance thus created to the roof of a house, it has received the expressive local name of "The Riggin".

In this district fine examples of glacial action can also be seen. Near Kilsyth the great basalt sheet has been carved by the ice into a succession of parallel "Roches Moutonnées", showing the characteristic flowing outline of ice-worn rocks. There are also many examples of buried river channels, now filled up with sand and clay. The bottom of some of these is actually below the present sea-level, thus showing that the district has subsided since the comparatively recent time when these channels were occupied by flowing rivers. A conspicuous example of one of these old river-beds forms in the Kilsyth coal-field what is known as a "sand dyke". It has been traced through the coal-field for a distance of several miles, running obliquely across the "Riggin".

The coal-seams of the Kirkintilloch and Kilsyth district are so very variable that it is almost impossible to give any generalized section. A seam which in one pit is of a workable thickness and quality may be found in an adjoining pit as a thin band of foul coal, and the strata between the seams undergo great changes in very short distances. The following is an average section showing the position of the Possil seams, with the corresponding section at Meiklehill, Kirkintilloch:—

General Section of Possil Coals

	Fms.	Ft.	Ins.
Calmy or Arden Limestone			
Hirst Coal...	0	3	0
Strata with thin coal seams ... about	65	0	0
Index Limestone	0	3	0
Strata			
Possil Upper Coal... ...	0	2	0
Strata	4	0	0
Possil Upper B.B. Ironstone	0	0	9
Strata	11	0	0
Wee Coal	0	1	0
Strata	5	0	0
Possil Main Coal	0	1	7
Strata	3	0	0
Braes o' Yetts Wee Coal...			
Strata ... ... 0 to	10	0	0
Possil Lower Ironstone ...	0	0	9
Strata	5	0	0
Knightswood Gas Coal ...	0	1	0
Strata	42	0	0
Garscadden Upper Blackband Ironstone			
Strata	10	0	0
Garscadden Lower Blackband Ironstone	0	1	2
Strata	3	0	0
Garibaldi Clay-band Ironstone			
Strata	4	0	0
Wee Coal	position		
Strata	6	0	0
Kilsyth Coking Coal ...	position		
Strata			
Hurlet Limestone			
Hurlet Coal...			

Section at Meiklehill

	Fms.	Ft.	Ins.
Calmy Limestone			
Strata (unknown) ...			
Chapelgreen Coal... ...	0	2	0
Strata	3	0	0
Coal (foul)	0	2	11
Strata	21	0	0
Index Limestone	0	5	0
Strata	16	0	0
Foul Coal	0	1	4
Strata	10	0	0
Coal	0	1	4
Strata	3	0	0
Meiklehill Main Coal ...	0	3	3
Strata, variable thickness with whinstone floats, say	50	0	0
Coal	0	1	0
Strata, with bands of Clay-band Ironstone	12	0	0
California Clay-band Ironstone	0	1	2
Strata	16	0	0
Coal (clean)	0	1	0
Strata	10	0	0
Coking Coal	0	3	6

I now give the section of Gartshore, compiled from the Geological Survey sections, and the corresponding section of the coals worked at Neilston, near Kilsyth:—

GARTSHORE, &c., SECTION	Fms.	Ft.	Ins.	NEILSTON SECTION	Fms.	Ft.	Ins.
Index Limestone ...	0	3	10				
Whin	18	4	0				
Strata	8	2	0				
Coal (Ins.) Coal 7 Blaes 3 Coal 10 Daugh 4	0	2	0	House Coal (Possil Upper)	0	2	2
Strata	4	0	0	Strata	4	0	0
Coal	0	0	9				
Strata	4	2	0				
No. 1 Ironstone (Ins.) Ironstone 5 Blaes 3½ Ironstone 2½ Craw Coal 3	0	1	2	Ironstone (Possil Upper)... position			
Strata	6	0	0	Strata	9	0	0
Foul Coal	0	0	6				
Strata	5	0	0				
Foul Coal	0	1	9	Smithy Coal	0	2	9
Strata	20	0	0	Strata	7	0	0
Meiklehill Main Coal ...	0	4	0	Soft Coal (Possil Main) ...	0	3	0
Strata	4	0	0	Strata	11	0	0
Foul Coal	0	0	7	Hard Coal	0	1	8
Strata	1	3	0	Strata	4	0	0
No. 2 Ironstone Gartshore Upper	0	0	8	Coal (Coking)	0	1	8
Strata	0	4	0	Strata	53	0	0
Coal (foul)	0	1	9				
Strata	3	0	0				
No. 3 Ironstone (Ins.) Craw Coal 8 Ironstone 7 Craw Coal 1 Blind Coal 3¼	0	1	7¼				
Strata	2	0	0				
Coal	0	2	3				
Strata	9	0	0				
Smithy Coal	0	2	0	Wee Coal	0	1	6
Strata	8	0	6	Strata	7	0	0
Coal	0	3	10	Kilsyth Coking Coal ...	0	4	3

The No. 1 Ironstone is equivalent to the Possil Upper Ironstone, and the No. 2 Ironstone to the Possil Lower Ironstone. The No. 3 Ironstone appears to occupy the horizon of some of the Garscadden Ironstone seams.

At Neilston Colliery, about ½ mile north-east of

Kilsyth, the coals have been tilted up at a high angle, dipping away from the Campsie hills, and they are being worked by mines from the outcrop. The "House Coal", which appears to correspond with the Possil Upper Coal, is of exceedingly good quality as a household coal. In common with the other Kilsyth coals, it has fine coking qualities, which add very much to its value. The other seams are also of very high quality as smithy and coking coals. The names which they have on the foregoing section are all descriptive of their quality. The seams below the Possil Upper Black-band Ironstone are known locally as "The Highland Park Seams". They appear to correspond with the coals worked at Denny and Bannockburn.

The variable nature of the strata is well illustrated by a bore recently put down at Allanfauld, only ½ mile west of Neilston. The seams found below the Possil Upper Ironstone were as follows:—

	Fms.	Ft.	In.
Possil Upper Ironstone			
Strata	28	0	0
Coal (Neilston Hard Coal)	0	1	8
Strata	4	0	0
Coal and Ironstone corresponding with Possil Lower Black-band Ironstone and the First Coking Coal of Neilston	position		
Strata	4	0	0
Coal (not found at Neilston)	0	1	10
Strata	5	0	0
Coal (not found at Neilston)	0	2	4
Strata	58	0	0
Position of Kilsyth Coking Coal.			

There are many faults traversing the district. The principal faults run about east and west, and have a displacement varying from 20 fathoms to nearly 200 fathoms. These faults are so numerous and so irregular that any attempt at a detailed description would serve no useful purpose. A shaft which is at present being sunk by Messrs. Wm. Baird & Co. is designed to work the coals on both sides of one of these faults. On the south side of the fault the seams are found at a depth of from 150 to 200 fathoms, but on the north side they will only be met with at the depth of 350 fathoms.

The quality of the coals is very well indicated by the fact that Messrs. Baird & Co. are prepared to sink to this depth to work such thin seams.

The ironstones worked at Kilsyth are smelted at Coatbridge. Twenty years ago the output of ironstone in Dumbartonshire amounted to over 350,000 tons per annum, but now the works are principally supplied with foreign ore, and the production of ironstone does not amount to one-tenth of the above figure.

A remarkable series of Clay-band Ironstones is also found at the position marked "Garibaldi and California Clay-band Ironstones" in the foregoing sections. In the Meiklehill shaft a bed of blaes is found 10 fathoms thick, containing eleven bands of ironstone, with an aggregate thickness of 5 feet. At Banton similar ironstones were found in the same horizon, some of the bands being over 1 foot thick, and exhibiting cone-in-cone structure. The Carron Iron Company wrought some of this Banton ironstone at the outcrop many years ago, and it is said that the iron produced was of good quality.

The Carboniferous Limestone series stretches eastward from Kilsyth towards Cumbernauld, where it dips under the Millstone Grit formation. At Banton, about 2 miles north-east of Kilsyth, a small basin occurs containing the coking coal which is known there as the Banton Main Coal. About 8 fathoms above this seam there is a smithy coal corresponding with the Wee Coal of Neilston, and 7 fathoms higher up was an Ironstone of remarkably good quality, known locally as the Banton Black-band Ironstone. This ironstone is not found in any of the other sections outside of Banton. The basin containing these seams is only about 300 acres in area, and is cut off on both sides by large faults. Below the Main or Coking Coal, there is a seam known as the Banton Lower Smithy

Coal, which is also local in its occurrence and has not been worked to any great extent. North-east of Banton the large fault throws up the Hosie and Hurlet Limestones. These seams dip towards the east, and are then overlain by the coals of Castlerankine, and the Denny and Bannockburn coal-fields.

In the Cumbernauld district the only workings which have taken place were on the outcrop of some of the coal-seams above the Index Limestone. The Under Hirst Coal is said to be a coking coal, and was looked upon as a valuable seam for that purpose. An important bore was put down by the Coltness Iron Company, near Dullater, to prove the coals below the Index Limestone. This bore is of considerable importance as throwing light on the probable continuation of the Kilsyth seams towards the east. Through the courtesy of the Coltness Company, I am enabled to give a complete journal of the bore.

JOURNAL OF BORE ON CUMBERNAULD ESTATE

		Fms.	Ft.	Ins.
Surface Soil		0	3	0
Moss		1	3	0
Clay and Stones		1	1	0
Sand and Gravel		4	0	0
Coal, Loose (Possil Upper)		0	1	0
Fireclay and Blaes		3	2	9
Fakes		0	2	0
Sandstone, Fakey		0	5	9
Fakes		1	0	6
Black Blaes		0	2	7
Ironstone	Possil Upper Ironstone	0	0	1
Fakes		0	1	6
Coal		0	0	11
Fakes and Coal Strains		0	1	6
Sandstone		2	0	6
Fakes and Blaes		0	1	11
Coal		0	1	1
Fakes and Balls		0	2	0
Sandstone		1	3	7
Hard Cuttery Sandstone		0	1	6
Sandstone, Limey		0	4	9
Sandstone		0	1	6
Black Blaes		0	1	10
Ironstone		0	0	1
Parroty Blaes		0	0	3
Parrot		0	0	4
Fakes and Sandstone		0	4	3
Fakes		0	1	8
Black Blaes		0	3	6
Fakes and Sandstone		0	2	0
Fakey Fireclay		0	0	10
Coal		0	1	1
Black Blaes		0	1	6
Sandstone		1	2	0
Black Blaes		1	2	4
Ironstone Rib		0	0	2
Black Blaes		0	1	8
Blaes and Balls		0	5	6
Black Blaes		0	0	3
Coal, Foul		0	1	8
Fireclay and Blaes		0	0	2
Coaly Blaes		0	0	5
Fakes and Blaes		1	3	10
Sandstone		3	3	4
Black Blaes		0	0	10

	Fms.	Ft.	Ins.
Coal (Wee Coal)	0	2	0
Coaly Fireclay	0	0	9
Black Blaes	0	4	10
Dark Fakes	0	1	4
Fakes and Sandstone	1	1	7
Fakes and Blaes	0	3	4
Coal	0	0	3
Dark Fakey Blaes	0	3	3
Coal (Main Coal)	0	1	5
Dark Fakes	0	0	9
Fakes and Sandstone	0	4	2
Sandstone (Coarse)	0	1	0
Blaes	0	2	3
Coal	0	0	5
Dark Fakes	0	0	4
Fakes and Sandstone	1	3	9
Black Blaes	0	5	3
Fakes and Sandstone	3	2	5
Blaes	0	0	9
Coal, Blind	0	0	9
Blaes	0	1	11
Coal, Blind	0	0	2
Fakes and Blaes	0	5	8
Black Blaes	1	0	8
Fakes	0	0	6
Coal, Blind	0	0	7
Fakes and Blaes	0	1	2
Fakes and Sandstone	0	5	8
Black Blaes	0	3	0
Irony Rib	0	0	3
Black Blaes	0	0	2
Coal	0	0	4
Black Blaes	0	1	6
Coaly Blaes	0	0	6
Fakes	1	1	3
Dark Fakey Sandstone	1	4	5
Light Fakey Sandstone	0	2	5
Blaes	0	0	1
Coal { Ins. Coal 4½, Parrot ½, Sclit ½, Coal 16½ } Knightswood Gas Coal	0	1	10
Stone	0	0	1
Coal	0	0	4
Fakes	0	0	6
Fakes and Sandstone	1	5	5
Black Blaes	0	2	0

	Fms.	Ft.	Ins.
Coal	0	0	8
Black Blaes	0	1	5
Coal	0	1	2
Fireclay	0	0	2
Fakes	0	5	4
Black Blaes	0	5	8
Ironstone Ball	0	0	3
Black Blaes	0	2	3
Coal	0	0	9
Fireclay	0	0	2
Fakes	0	5	1
Sandstone	3	1	0
Black Blaes	2	2	7
Coal	0	1	0
Fireclay	0	0	6
Fakes	1	1	9
Coal, Blind	0	0	4
Fakey Fireclay	0	0	6
Fakes and Balls	0	5	6
Fakes and Sandstone Ribs	2	0	5
Coal	0	1	0
Fakes and Sandstone	1	4	0
Fireclay	0	0	3
Gray Fakes	3	4	4
Black Blaes	0	1	7
Dark Fireclay	0	0	11
Fakes and Balls	0	2	8
Sandstone	7	5	0
Black Blaes	0	2	0
Fakes	0	0	3
Coal	0	0	5
Sandstone, Black	0	0	2
Coal	0	0	5
Fireclay	0	1	0
Fakes and Balls	0	2	1
Coal	0	0	6
Fakes and Sandstone	1	3	1
Fakes	2	0	0
Black Blaes	1	1	10
Ironstone (Mussel-band)	0	0	3
Blaes (Mussel)	0	1	5
Ironstone (Mussel-band)	0	0	2
Black Blaes	0	1	4
Ironstone Ball	0	0	2
Black Blaes and Ironstone Ribs	2	0	6
Hard Blue Blaes and Ironstone Ribs	2	4	10

	Fms.	Ft.	Ins.
Light Fakes and Balls, broken	1	4	4
Calmy Fakes	2	5	10
Whinstone	45	3	0
Fakes and Sandstone	3	1	2
Hard Sandstone	0	0	10
Fakes and Sandstone	3	2	7
Black Blaes	0	5	0
Fakes and Sandstone	3	1	8
Black Blaes	2	0	9
Fakes, Blaes, and Iron Balls	0	3	9
Fakes and Sandstone	1	3	0
Fakes	0	2	0
Black Blaes	0	5	7
Limey Ball	0	0	6
Blaes and Balls	0	5	2
Fakes	0	0	9
Coal	0	0	6
Fakes	0	2	3
Black Blaes	0	4	10
Ironstone Rib	0	0	4
Black Blaes	1	2	0
Fakes	0	2	2
Coaly Blaes	0	0	2
Coal	0	0	9
Black Blaes	0	1	1
Fakes	0	4	3
Black Blaes	1	1	2
Fireclay and Blaes	0	1	2
Coal, burnt, hard	0	0	1
Ironstone Rib	0	0	1
Coal, burnt, hard	0	0	1
Ironstone Rib	0	0	1
Black Blaes	0	3	3
Fireclay and Blaes (soft)	0	1	0
Coal	0	0	5
Fakes	0	4	6
Coal	0	0	2
Fakes and Sandstone	2	2	5
Black Blaes	0	3	7
Fakes	0	3	4
Coal	0	0	4
Fakey Fireclay	0	0	4
Dark Fakes	0	4	8
Sandstone	0	1	9
Fakes and Sandstone	0	5	0
Fakes	0	2	6
Black Blaes	1	1	9

	Fms.	Ft.	Ins.
Coal, hard, burned	0	0	8
Black Blaes	0	0	6
Fakes and Sandstone	0	4	0
Hard Sandstone	0	2	4
Fakes and Blaes	1	5	8
Black Blaes and Balls	1	5	0
Sandstone, with Coal Strains	0	0	2
Coarse Dark Sandstone	1	4	0
Light Sandstone	0	4	10
Fakes and Sandstone	1	3	1
Sandstone	0	2	1
Gray Fakes	0	5	3
Coarse Sandstone	0	4	10
Fakes	0	2	0
Fireclay and Coal Strains	0	0	8
Fakes and Sandstone	0	3	3
Fakes	0	5	0
Black Blaes	0	2	0
Fakes	0	1	6
Black Blaes	1	3	0
Sandstone	2	1	4
Coal, Blind	0	0	7
Dark Fakes and Balls	1	3	3
Fakey Sandstone	0	1	6
Dark Fakes, Coaly	0	0	8
Fakes and Sandstone	2	1	2
Black Blaes	1	4	4
Limey Rib	0	0	1
Sandstone	2	2	10
Fakes and Sandstone	2	1	0
Coarse Sandstone	0	1	6
Coal, Blind	0	0	5
Sandstone	2	5	0
Fakes and Sandstone	0	1	2
Dark Fakes	0	5	9
Black Blaes	3	2	3
Hard Fake Rib	0	0	6
Black Blaes	2	5	10
Dark Fakey Blaes	0	1	0
Light Fakes	0	0	10
Dark Fakes	0	2	10
Black Blaes	9	1	2
Hard Fakes, Limey	2	3	3
Black Blaes	1	3	0
Limestone (Hosie)	0	1	1
Limestone Fake	0	0	6
Total Depth of Bore	229	4	4

I have marked on the journal what may be taken as the position of the Kilsyth seams, but this of course can only be guesswork. In a bore put down by Messrs. William Baird & Co. at Bedlay, near Chryston, the results were somewhat more favourable. The Kilsyth coking coal was found 2 feet 7 inches thick, at a depth of 182 fathoms.

To the south-west of Kirkintilloch the Carboniferous Limestone measures stretch by Cadder and Robroyston until they are thrown down by the boundary fault of the Lanarkshire coal-field. The coals of that district are described along with the Garscube and Possil sections on page 134.

To the north-west of Kirkintilloch the Limestone measures dip into a basin, and are covered by the Millstone Grit. The Hirst Coal was opened up in this district by a pit at Hayston, on the Kelvin Valley railway, about 1 mile east of Torrance station. The coal was found to be very poor in quality, and mixed with bands of dirt, and the working was abandoned. Near Torrance a bore was put down, in 1872, to a depth of 165 fathoms. The Hirst Coal was found 4 feet 8 inches thick at 12 fathoms. The Cowglen Limestone, 5 feet thick, was reached at 121 fathoms. A coal, 1 foot thick, corresponding possibly with the Possil Wee Coal, was found at 156 fathoms, and 2 fathoms below that, a coal 2 feet 2 inches, corresponding with the Possil Upper Coal. At 162 fathoms there was a coal-seam 1 foot 8 inches thick, and the bore stopped 3 fathoms below this. The ironstone seams were absent, or represented only by bands a few inches thick. Another bore was put down in the same locality in 1873, but the only coal-seam met with, over 8 inches in thickness, was a seam at 149 fathoms deep and 20 inches thick. It would thus appear that there is a stretch of barren ground separating the Kirkintilloch coal-field from the coal-fields of Possil and Garscadden.

The coal-field is cut off a little to the north of this bore by a large fault which trends north-eastward to Milton. The displacement caused by this fault must be about 200 fathoms, with an upthrow to the north. The Calmy Limestone is found at the surface on the south side of the fault, and about ¼ mile to the north of the fault the Hurlet Limestone is found cropping out.

At Lennoxtown and Campsie the Hurlet Limestone and Coal have been extensively worked. The geology of this district has been described in detail in a very interesting paper by Dr. John Young, F.G.S., published in the *Transactions of the Geological Society of Glasgow* (vol. i, part 1). Mr. Young gives the following account of the working of those seams:—

"In the Campsie district, immediately under the Main Coal, there is a bed of cement-limestone, between 4 and 5 feet in thickness. It has been termed the 'White Limestone', being of a light cream colour after exposure to the weather, and, like the limestone at the Linn of Baldernock, formerly mentioned, is also apparently of fresh-water or lacustrine origin, as it abounds with the shells of *Carbonia fabulina.*

"The Main Coal of the Campsie district is separated from the White Limestone by about 7 inches of 'underclay', and from the overlying Main (Hurlet) Limestone by the alum shale, which is about 2 feet thick, on the South Hill, while on the North Hill, on the opposite side of the valley, it attains a thickness of about 14 feet. In the latter locality this shale is rich in alum only in the lower portion of the bed contiguous to the coal. In some parts of the South Hill the alum shale passes into a sulphurous black-band ironstone, which is likely, if worked, to prove neither very persistent over any great area, nor of good quality, owing to the abundance of sulphur it contains.

"The coal averages 3 feet 8 inches in thickness, but is of inferior quality, especially along the North Hill, where it is much deteriorated by thin bands and nodules of iron pyrites. It was formerly much used in the district for household purposes; but now that the finer coals of the Upper Coal-measures are imported by the railway, the local deposit is drawn upon chiefly for use in the public works, and for burning the limestone.

"The Main Limestone of the Campsie district has long been famous, when calcined, for agricultural purposes, and as a building material . . . In the parish there is a tradition that the lime used in the erection of the High Church (Cathedral) of Glasgow was taken from the south braes of Campsie."

In the parish of New Kilpatrick the ironstones have been all worked out at Knightswood and Garscube, and also the well-known Knightswood gas coal, and the old blaes heaps produced from those workings have in many cases been converted into bricks, and the burnt blaes are being used up for paving purposes.

The only coal-working now being carried on is in the Hurlet Coal at Baljaffrey Colliery. The workings there are of very ancient date, and are partly drained by an old day level driven from the low-lying ground south of the Duntocher road. There is still a very large area of the Hurlet Coal, with its associated Limestone, throughout the whole of this district, southward to the Clyde, where it passes into the county of Renfrew, and it may be possible to work this seam at some future date, together with some areas of the Possil Main Coal which are still intact in the vicinity of Drumchapel and along the northern banks of the Clyde. The section of the Hurlet seam at Baljaffrey is as follows:—

	Ft.	Ins.
Limestone	3	0
Alum Shale	0	6
Coal	0	10
Blaes	0	1
Coal	0	7
Blaes	0	1
Coal	0	7
Blaes...	0	0½
Coal	2	1

The coal contains a high proportion of iron pyrites. These pyrites are separated from the coal and sold to chemical manufacturers.

On Craigmaddie Muir, about 1 mile to the south of Lennox Castle, there are some old coal-pits which were apparently used for working the Hurlet Coal. At Linn, 1½ mile north-north-west of Balmore, some old workings in the Hosie Limestone and oil shale are still open, and can be entered by a day level from the glen. The limestone is overlain there by a sheet of dolerite, and, as exposed in the glen and in the old workings, forms a very interesting geological study.

CHAPTER VII

Stirlingshire

Slamannan Coal-Field.—The Slamannan coal-field has long been famous as a producer of a very high quality of steam coal. The area in which the steam coals are principally worked lies to the south of the village of Slamannan, and would be more correctly described as the Longriggend coal-field.

It consists of a strip about 6 miles long by 3 miles wide, with the mining village of Longriggend in the centre, and lies partly in the county of Lanarkshire and partly in the county of Stirlingshire.

This area is bounded on the north by one of the great trap dykes which run east and west across the Scottish central coal-field. In the Slamannan district this dyke occupies the line of a fault with a downthrow to south of 70 to 80 fathoms.

On the west the coal-field merges into the Greengairs and Airdrie coal-fields, and on the south and east it is bounded by faults and the outcrops of the coal and underlying whin. The following is a section of the seams:—

Section at Longriggend

	Fms.	Ft.	Ins.
Johnstone Coal (Virtuewell)	0	2	6
Strata	7	0	0
Ladygrange Coal (corresponding with Bellside Black-band Ironstone)	0	2	0
Strata	2	0	0
Coal	0	1	1
Strata	15	0	0
Mussel-band Shale and Ironstone... ...	0	1	2
Strata	7	0	0
Splint Coal (Kiltongue)	0	2	0
Strata	14	0	0
Coxroad Coal (Drumgray)...	0	1	10
Strata	5	0	0
Balmoral or Lower Coxroad (Lower Drumgray)	0	2	6

From the Balmoral Coal to the position of the Slatey-band Ironstone at the base of the Coal-measures there is a distance of about 40 fathoms. Throughout the Longriggend district this space is mostly occupied by an extensive sheet of intrusive dolerite which has more or less burnt the overlying coals, and it is this burning which has altered the seams so as to make them into steam coals and anthracite.

This dolerite sheet appears to have had its origin at some point north of Slamannan. In the vicinity of Falkirk it occupies a position about the base of the Millstone Grit, and seems gradually to rise higher in the stratigraphical horizon as it passes to the south and south-east. It is seen coming to the surface at the east and south of the Longriggend field, forming a line of crags from about Avonbridge to Westcraigs, and it there occupies a position close below the Coxroad or Lower Drumgray Coal. It is highly probable that it stretched in a continuous sheet over the Shotts, Harthill, and Benhar coal-fields. In those districts it occupies a higher stratigraphical position than in Slamannan district, and overlies the Drumgray coals. The whin here is at the surface, and has been to a considerable extent removed by denudation. Sufficient still remains to indicate its former extent, and the fact that it was once there is also shown by the circumstance that many of the seams throughout those districts have been burned. As there is no underlying whin at Shotts, Benhar, &c., which might have caused the burning, the natural assumption is that it was caused by a whin formerly above the coals but now removed by denudation.

In the eastern part of the Longriggend district the Coxroad coal is burnt so as to be almost useless. At Arnloss some attempt was made to work it for anthracite purposes. Although the analysis showed 87 per cent of carbon, the physical condition of the coal was bad, being sooty and lustreless. It was also very soft, and was thus of limited commercial utility.

At Eastfield, near Caldercruix, the Coxroad Seam has been formed into a hard anthracite with a steely-blue lustre, resembling the Welsh anthracite.

The following is an analysis of this seam, which is being extensively worked by Messrs. James Nimmo & Co.:—

		Per Cent.	
Volatile Matter	Gas, Tar, &c.	9.01	11.20
	Sulphur	.11	
	Water	2.08	
Coke	Fixed Carbon	85.15	88.80
	Sulphur	.79	
	Ash	2.86	
			100

The specific gravity is 1.363; and 1 lb. of coal evaporates 11.34 lbs. of water.

At Lochend the Splint Coal is being worked as an anthracite, and is of similar quality to the above; but throughout most of the district it is found to contain about 77 to 80 per cent of carbon. It forms a practically smokeless coal, possessing a calorific value equivalent to 10.6 lbs. of water evaporated by 1 lb. of coal.

Although in many other parts of Scotland coal-seams have been burnt by the action of whinstone, and have been converted over small areas into anthracite and steam coals, there is no other instance in which a large area such as found at Longriggend has been affected with so great regularity. The reason here is that the whinstone forms a great mass lying about parallel with the coal-seams, but at a considerable distance from them. The fact that it underlies the seams probably tends to make the alteration of the coal more regular.

The steam coals and anthracite coals of Wales are much more regular than the coals of the Longriggend field, but in that case the burning has resulted from quite a different cause. The whole of the Welsh coal-field has at some geological period been subject to a great depression, whereby it was sunk to such a depth that the coals became altered by the natural heat of the earth due to a depth of say 40,000 to 50,000 feet. In that case the western portion of the field was sunk to a greater depth than the eastern portion, and the seams in the west, being thus subjected to greater heat, have been formed into anthracite coals, while the seams in the eastern portion of the field have been formed into steam coals.

The Welsh steam coals are for this reason more regular and reliable than the Slamannan steam coals. Attempts have been made to get the Slamannan coal introduced into the navy, but the Admiralty have not yet seen their way to adopt it.

In the Splint Coal seam at Slamannan a want occurs which traverses a considerable portion of the field, and is thus described in the Memoirs of the Geological Survey:—

"It runs approximately east and west, with a somewhat bent course. The breadth of the actual blank space is not easily known, for mining operations are put a stop to as soon as the coal thins out so as no longer to be worked to a profit. The explanation of this structure appears to be that, during the formation of the material which went to make the coal, a water-course traversed the area in the direction of the want and removed the decaying vegetable matter so as to expose the bed of clay on which it rested before the change of conditions took place which brought in the sediment now forming the roof of the coal. The beds which elsewhere form the roof and pavement of the coal come together where the coal has disappeared."

The coal being of very good quality, with a strong roof and fireclay holing, it has been worked at places along the want where the thickness does not exceed 12 inches.

The Johnstone Coal, although not of as high a quality as the underlying seams, has been extensively worked along with a bed of oil shale which is found immediately overlying it, and generally from 4 inches to 8 inches thick. The same shale-seam has been worked extensively in the district west of Longriggend. At Stanrigg, oil works were erected for treating it. It is also used as a gas coal. The Johnstone seam is now practically exhausted.

In the districts to the east of Slamannan the position between the Lower Drumgray Coal and the Slatey-band Ironstone contains a valuable series of coal-seams. Expectations were entertained that some of those lower coals might prove valuable in the Longriggend area, and thus take the place of the upper seams, which are now becoming rapidly exhausted. No bores have yet been put down through the whinstone in the western part of the field, but a bore put down at Binniehill, near the North British Railway, passed through the position of all the seams to the Slatey-band Ironstone without finding any coals more than a few inches thick. On the other side of the coalfield at Brownieside, near Plains, those seams are also absent. At Binniehill the whinstone sheet underlies the Slatey-band Ironstone. It then rises through the metals coming farther south, as already mentioned, so that even if the coals had been present in the Longriggend field, they would have been destroyed over most of the area by this whinstone.

In the district to the north of the 70-fathoms fault and whin gaw, several bores have been put down in search of coal-seams below the position of the Slatey-band Ironstone. At Pirney Lodge, ¾ mile east from Slamannan station, a seam of coal 1 foot 6 inches thick, with a good roof and holing, was found at a depth of 17 fathoms below what was supposed to be the Slatey-band Ironstone, the depth from the surface being 35 fathoms.

Another bore was put down about ¾ mile to the west of Slamannan village, at Middlerigg. Messrs. James Nimmo & Co. have supplied me with the journal of the bore, of which the following is an abstract:—

Journal of Strata found in Bore at Middlerigg, Slamannan

	Thickness of Strata			Depth from Surface		
	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Surface	4	0	6			
Sandstone	0	3	6			
Fakes and Blaes	0	3	0			
Sandstone, broken	0	1	0			
Coal (Loose)	0	1	5	5	3	5
Fireclay	0	0	6			
Fakes and Blaes	4	5	0			
Coal	0	0	2			
Light Fireclay	0	1	2			
Fakes, Blaes, and Sandstone	3	4	3			
Irony Fakes	0	0	3			
Blaes and Balls	0	2	7			
Blaes and Mussel-shells	0	0	3			
Parrot (coarse)	0	0	1			
Coal	0	1	2	15	0	10
Light Fireclay	0	1	0			
Fakes and Sandstone	4	4	4			
Light Fireclay	0	2	0			
Fakes and Fireclay	0	2	10			
Coal, soft	0	0	4	20	5	4
Sandstone	1	5	10			
Blaes and Balls	0	0	8			
Ironstone B.B. (Slatey-band Ironstone)	0	0	5			
Coal (Slatey-band Ironstone)	0	0	2	23	0	5
Fakes and Sandstone	1	3	0			
Dark Fakes and Coal	0	0	9			
Light Fakes	0	2	6			
Sandstone	2	4	7			
Fakes and Sandstone	1	5	0			
Hard Sandstone	0	2	6			
Fakes and Blaes	0	1	2			
Mussel Blaes	0	1	11			
Ironstone B.B.	0	0	3			
Sandstone	0	5	6			
Strata	4	1	7			
Ironstone (coarse)	0	0	3			
Dark Blaes	0	0	3			
Blaes and Coal	0	0	4			
Coal	0	0	6	36	0	6
Fakes	0	1	11			
Light Blaes and Ironstone Ribs	2	0	0			
Dark Blaes	0	0	4			
Coaly Fakes (coarse)	0	0	6			
Coal, clean	0	1	8	38	4	11
Dark Fakes	0	0	4			

	Thickness of Strata			Depth from Surface		
	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fireclay and Blaes	0	1	0			
Sandstone	3	3	0			
Coal, soft	0	0	10			
Fakes and Blaes	0	2	3			
Coal	0	0	2	43	0	6
Light Fireclay	0	3	0			
Fakes	0	0	10			
Sandstone	3	2	6			
Light Fireclay	0	2	0			
Fireclay and Blaes	0	1	4			
Fireclay and Coal	0	1	0			
Sulphur Rib and Ball	0	0	3			
Faky Fireclay	0	2	1			
Sandstone	6	1	11			
Fakes and Sandstone	0	1	0			
Fireclay	0	0	9			
Dark Blaes	0	1	0			
Fireclay	1	1	8			
Coal	0	2	4	56	4	2
Fakes and Coal	0	0	4			
Fireclay	0	1	4			
Dark Fakes	0	1	6			
Sandstone	0	1	0			
Fireclay	0	0	′			
Sandstone and Fakes	10	3	5			
Coal	0	0	3	68	0	6
Sandstone and Fireclay	4	5	4			
Sandstone, hard	0	1	6	73	1	4

About 1½ mile north of the Middlerigg bore a deep bore was put down by the Carron Company at Easter Jaw. I have not received details of this bore, but have been informed that it reached a depth of about 300 fathoms. The positions of the Armadale Ball and Main Coals were found, but too thin to be workable. The Millstone Grit metals were found quite regular, but after that the strata were apparently disturbed, and the last 30 to 40 fathoms of the bore was in "volcanic ash".

The famous steam coals of Slamannan are now almost exhausted. It is a curious study in place-names that most of the properties in the district have the affix "rigg", as Longrigg, Middlerigg, &c., and this affix has become so closely associated with the Slamannan steam coal that it has been found necessary to add "rigg" to the name of new collieries which have been opened up in other districts to work similar seams!

The coals of the Slamannan coal-field stretch northward to the River Forth at Grangemouth and Carron, and are thus connected with the Clackmannanshire coal-field.

The lower seams of the Coal-measures come to the surface a short distance north of Falkirk and Camelon, and are succeeded by the Millstone Grit, but about 1 mile farther north there is a large east-and-west fault which again throws down the Coal-measures strata, and these measures then continue northward and pass under the River Forth.

The following general section of the economic minerals in the Falkirk coal-field is taken from the Geological Survey memoir.

It will be observed that the seams underlying the Drumgray coals as developed here are somewhat similar to those of the Armadale district. The Bonnyhill Craw Coal occupies a position corresponding with the Colinburn Coal of Armadale.

The Brighton Main and Gutterhole Seams probably correspond with the Armadale Mill and Ball Coal Seams.

SECTION OF FALKIRK COAL-FIELD

	Fms.	Ft.	Ins.
Strata	2	0	0
Ironstone	0	0	2
Coal, Parrot	0	0	3
Blaes	0	0	3
Coal	0	1	2
Strata	0	1	6
Coal (Virtuewell, Four-foot, Cockmalane, or Diamond)	0	4	0
Strata	3	0	0
Oil Shale	0	2	0
Coal, Parrot	0	0	2
Ironstone	0	0	3
Blaes	0	0	6
Coal	0	0	2
Strata	5	0	0

		Fms:	Ft.	Ins.
	Coal	0	1	4
	Strata	7	0	0
	Shell-bed	0	1	4
	Blaes and Ironstone	0	1	0
	Coal (Miller or Carron Two-foot)	0	1	6
	Strata	10	0	0
	Coal, Craw, with 6 ins. parting	0	3	6
	Strata	7	0	0
	Shell or Mussel-band	0	1	0
	Strata	2	0	0
	Coal (Splint or Main Coal, Kiltongue Coal)	0	3	0
	Strata with about 8 fms. Sandstone	2	0	0
Drumgray Coals	**Coal, Coxroad or Soft**	0	2	6
	Strata	3	0	0
	Coal, Low Coxroad or Balmoral Coals	0	2	0
	Strata with 6½ fms. Sandstone	15	0	0
Auchingane Coal (Shotts Parrot Coal)	**Ironstone, Clay-band**	0	0	4
	Blaes	0	0	6
	Ironstone, B.B.	0	0	6
	Coal, Parrot	0	0	8
	Coal, Soft	0	1	2
	Strata with Sandstone of 4 fms.	9	0	0
	Blaes with 2 ribs of Clay-band Ironstone	0	4	6
	Coal, Brighton Main, with 2 ribs of stone	0	5	0
	Strata, chiefly Sandstone	4	0	0
	Coal, Gutterhole or Glenfuir, with 6 ins. stone	0	3	6
	Strata	1	2	0
	Coal	0	1	0
	Strata, chiefly Sandstone	4	0	0
	Coal	0	1	0
	Strata	0	1	0
	Ironstone, Black-band	0	0	3
	Blaes	0	2	0
	Ironstone, Black-band	0	0	4
	Blaes	0	1	11
	Ironstone, Clay-band	0	0	2
	Blaes	0	0	2
	Ironstone, Clay-band	0	0	6
	Strata	0	2	4
	Bonnyhill Upper Stone, Clay-band	0	0	4
	Fireclay	0	2	3
	Coal, Bonnyhill Upper Stone Coal	0	1	0
	Strata, including 3 fms. Sandstone	3	3	9
	Coal, Bonnyhill Craw	0	1	0
	Strata	1	0	0
	Ballstone, Clayband	0	0	6

	Fms.	Ft.	Ins.
Strata, including 2 fms. Sandstone ...	3	1	0
Ironstone, Black-band	0	1	9
Daugh	0	0	3
Ironstone, Black-band	0	1	2

Those coal-seams have been worked for many years at Falkirk, Polmont, Stenhousemuir, and Carron. The ironstone seams are not now being worked. The whole output of ironstone in the eastern district of Stirlingshire amounts only to a few thousand tons, principally from local deposits in connection with the coal-workings.

A large east-and-west fault, with an upthrow to the north, runs across the country about 1½ mile north of Grangemouth. There has been very little coal-working on the northern side of that fault.

Some pits were opened up a few years ago to work some of the under-seams of the Falkirk section, on Airths Moss, but the coal was found to be of a very inferior quality, and the working was abandoned.

The section of the shaft was:—

	Fms.	Ft.	Ins.
Strata	21	0	0
Coal	0	2	4
Strata	4	4	0
Coal	0	2	0

In a bore about ½ mile north-east of the shaft the section was as follows:—

	Fms.	Ft.	Ins.
Strata	17	0	0
Coal	0	1	9½
Strata	9	1	6
Coal	0	2	0
Fireclay	0	1	8
Coal	0	0	10½
Strata	13	4	0
Coal	0	2	3

It is supposed that the lowest coal in this bore is the same seam as the lower seam found in the pit.

Several bores have been put down along the shores of the Forth, disclosing various seams of coal which probably correspond with the lower seams found at Alloa and Kincardine. The surface is covered with a thick coating of the alluvial silt of the Forth, obscuring the coal outcrops, and making the exploration of the field somewhat difficult. Coals were recently worked at Dunmore, near the River Forth, about 2 miles below Alloa Bridge. There appears to be a considerable area of coals in this district which may be profitably worked at some future time.

The following abstract of a bore put down near Dunmore gives a fair idea of the coal-seams which may be met with:—

SECTION OF COALS FOUND IN BORE AT DUNMORE

	Fms.	Ft.	Ins.
Strata	15	5	0
Coal	0	1	0
Strata	0	4	9
Coal 1 ft. 4½ ins. Coal, Gas 0 ft. 5 ins.	0	1	9½
Strata	10	0	11
Coal, Wild Gas 0 ft. 4 ins. Free Coal 1 ft. 8 ins.	0	2	0
Strata	13	2	5
Coal, Hard Splint	0	2	5½
Strata	7	2	9
Coal	0	1	11
Strata	4	0	4
Depth	53	1	4

The Denny and Bannockburn coal-field occupies an intermediate position between the coal-fields of Kilsyth and West Fife. The Carboniferous Limestone measures of West Fife disappear below the Millstone Grit, and after passing through a deep basin below the Coal-measures of Alloa and Grangemouth the Upper Limestone comes to the surface again about 3 miles west of Alloa. (See section on Plate XI.) The Lower Limestone comes to the surface near Stirling, and strikes southward to the large fault which brings down the Coal-measures at Dennyloanhead. The most of the Bannockburn area is held in lease by the Alloa Coal Company, and the coal-seams are being worked from two shafts sunk in 1893–95.

By the courtesy of Mr. Jas. Bain of the Alloa Coal Company I am enabled to give the following section of the coals intersected in these shafts:—

SECTION OF THE BANNOCKBURN COAL-FIELD

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Surface and Clay	10	4	6			
Strata	19	0	0			
Limestone	0	2	3	30	0	9
Coal	0	0	4½			
Strata	8	0	3½			
Coal	0	0	2	38	1	7
Strata	0	1	1			
Coal	0	0	9	38	3	5
Strata	4	4	3			
Coal	0	0	10	43	2	6
Strata	0	2	11			
Coal	0	0	2	43	5	7
Strata	10	0	11			
Coal	0	2	2	54	2	8
Strata	17	3	1½			
Coal	0	0	10½	72	0	8
Strata	7	2	10			
Coal	0	1	0	79	4	6
Strata	4	2	6			
Coal	0	0	3	84	1	3
Strata	12	3	1			
Limestone (Index)	0	3	0			
Strata	0	1	4			
Coal	0	0	3	97	2	11
Strata	5	2	1			
Coal	0	0	3	102	5	3
Strata	1	1	1			
Coal	0	0	6	104	0	10
Strata	6	0	2			
Coal	0	0	6	110	1	6
Strata	5	2	9			
Coal	0	1	2	115	5	5
Strata	3	3	5			
Limestone	0	1	2	119	4	0
Strata	1	0	0			
Coal	0	0	4	120	4	4
Strata	4	5	4			
Black-band Ironstone (Denny)	0	0	10	125	4	6
Strata	4	3	6			
Coal	0	1	4	130	3	4
Strata	1	0	2			
Coal (Greenyard)	0	2	4	131	5	10
Strata	4	0	0			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Coal	0	1	0	136	0	10
Strata	6	1	10			
Coal (Auchenbowie)	0	1	10	142	4	6
Strata	5	3	9			
Coal	0	0	10	148	3	1
Strata	3	0	11			
Coal	0	1	4	151	5	4
Strata	7	2	3			
Coal	0	3	3	159	4	10
Strata	0	4	9			
Coal (Bannockburn Main) ...	0	3	6	161	1	1
Strata	6	0	0			
Coal (Knott)				167	1	1
Strata	26	0	0			
Coal (Milton)						
Strata	40	0	0			
Limestone				207	1	1

The shafts are sunk at the outcrop of the Hirst Coal. The position of the Calmy Limestone is about 8 fathoms above the Hirst Coals, and about 80 fathoms above that again is the Castlecary Limestone.

The strata dip towards the east at an inclination of about 1 in 7.

The only two seams which have been worked to any extent are the Greenyard and the Bannockburn Main Coal.

Both these seams are of exceptionally good quality, as is shown by the following analysis made by Mr. George R. Hislop, F.C.S., &c., Paisley.

Analysis of Greenyard Coal Seam (known commercially as the Bannockburn Hartley Steam coal):—

Mean Specific Gravity, 1.275.

PROXIMATE ANALYSIS

The coal when distilled at 2000° Fahr. yields:

			Per Cent.
Volatile Matters	Gas, Tar, &c. ...	31.88	34.98
	Sulphur	.30	
	Water at 212° ...	2.80	
Coke	Fixed Carbon ...	61.69	65.02
	Sulphur	.21	
	Ash	3.12	
			100.00

Coke per ton of coal ... ... 1455.776 lbs.

ULTIMATE ANALYSIS

Constituents of Coal.	Per Cent.
Carbon	82.047
Hydrogen	4.965
Nitrogen	1.215
Oxygen	5.340
Sulphur	.514
Ash	3.119
Hygroscopic Water	2.800
	100.000

Calorific or heat-producing power of the coal determined by Thomson's Calorimeter:—1 lb. of the coal, by perfect combustion, evolves heat sufficient to convert 14.55 lbs. of water from 212° Fahr. into steam.

REMARKS.—The foregoing results prove this to be an excellent coal for steam-raising purposes, containing as it does 87.42 per cent of purely heat-giving elements and a very moderate percentage of both ash and water. As a household coal also, this is entitled to high commendation, since it possesses all the essential characteristics of a first-class house coal.

Analysis of Bannockburn Main Coal Seam (known commercially as the Bannockburn Wallsend Drawing-room Coal):—

ANALYSIS OF BANNOCKBURN WALLSEND DRAWING-ROOM COAL. (MAIN COAL SEAM.)

MINERALOGICAL CHARACTERS

The coal is black and of high lustre; while in fracture it is irregular, and in cross-fracture columnar and highly crystalline in structure, and of very uniform composition and density; mean specific gravity being 1237 (water 1000), and the weight of one cubic foot 77.31 pounds. It is moderately cohesive, but very compact and without a trace of lime or pyritic impurities.

CHEMICAL ANALYSIS

	Per Cent.
Volatile Matters	29.10
Fixed Carbon	66.50
Ash	2.10
Sulphur	.05
Water	2.25
	100.00

Heating power of the coal as determined by Thomson's Calorimeter:—1 lb. of the coal by perfect combustion evolves heat sufficient to convert 14.85 lbs. of water from 212° Fahr. into steam.

REMARKS.—As a household coal this is one of the finest and purest that I have had occasion to examine. It contains exceptionally small percentages of ash, water, and sulphur, possesses great heating power, durability, and freedom from smoke, and is therefore an exceptionally fine Drawing-room Coal.

The following is the chemical analysis of the foundry coke made from the above coal:—

	Per Cent.
Carbon	96.68
Sulphur	.36
Ash	2.90
Water	.06

The specific gravity of the coke is .661.

The Bannockburn Main Coal was formerly worked along the outcrop, but these workings were abandoned about thirty years ago, and there were no workings in the coalfield until the Alloa Coal Company commenced operations in 1893. Very heavy water was met with in these sinkings, and pumping machinery has been erected which is capable of raising over 1500 gallons of water per minute.

The Knott Coal and the Milton Coal have not yet been worked, but they are known to be of a workable thickness, and may be opened out in the future.

The Milton Coal appears to correspond with the Kilsyth Coking Coal, and with the Dunfermline Splint Coal. The Bannockburn Main probably corresponds with the Neilston Coal of Kilsyth, and may represent the Lochgelly Splint Coal of Fifeshire.

The Greenyard Coal occupies a position corresponding approximately with the Meiklehill Main Coal and the Fourteen-foot Coal of Fifeshire, but it is impossible to establish any exact relationship.

Passing southward from Bannockburn, most of the coal-seams thin out. At Denny the Greenyard seam is known as the Garth Coal. It is only 20 inches thick, with a parting of about 7 inches in the centre. The Bannockburn Main Coal, in the Denny district, is from 1 foot 5 inches to 3 feet thick, but none of the other seams are known to be of a workable thickness throughout any large area.

The coal-seams at Denny have been slightly burned, probably by an underlying whin, and have thus been converted into smithy coals of a very high quality. At Castlerankine, near Denny, the Main Coal contains 73 per cent of coke.

The Denny Black-band Ironstone has the following section:—

	Ft.	Ins.
Parrot Coal...	0	2
Black-band Ironstone	1	3
Daugh	0	1
Parrot Coal...	0	4

The position of this Ironstone corresponds with one or other of the Upper Ironstones of Kilsyth, and with the Possil and Lochgelly Ironstones.

Some Clay-band Ironstones were formerly worked near Dunipace. These Ironstones were probably in the horizon of the Garibaldi Clay-band Ironstones.

As mentioned in a previous chapter (p. 14), the strata of the Denny coal-field do not correspond either with the strata found at Kilsyth or with the strata found at Bannockburn. During the oscillation of level which occurred during the period when this part of the Carboniferous Limestone series was being deposited, the Denny area must have been subjected to physical conditions differing considerably from those obtaining in the adjoining areas, with the result that there are frequent overlaps, and few of the individual beds can be traced continuously from the one coal-field to the other.

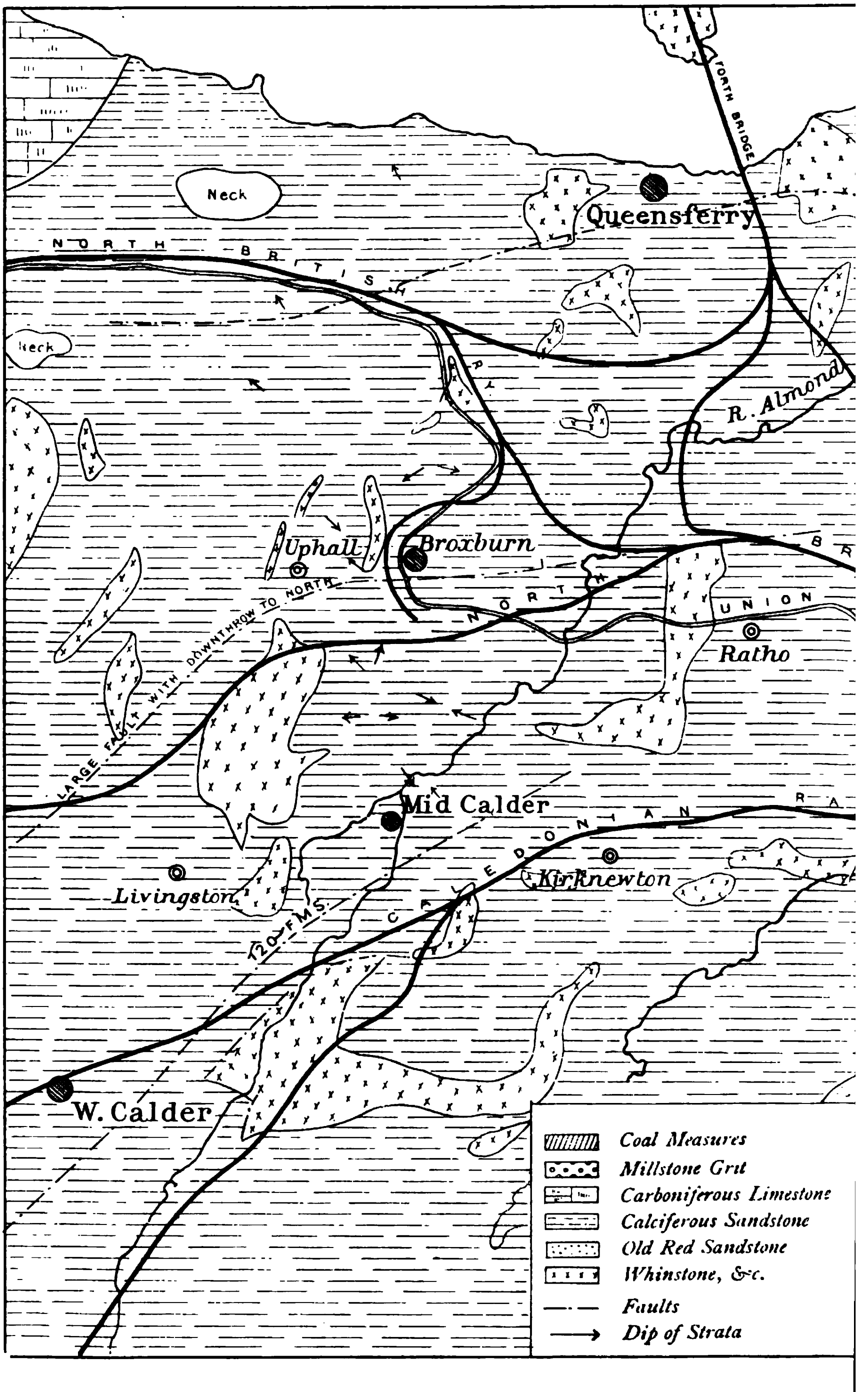
That the Coal-measures of Lanarkshire stretched originally across the country to Alloa and Fifeshire is proven by the existence of a small detached area containing those measures at Banknock. This coal-field is bounded on the south by a large east-and-west fault, which throws down the Coal-measures against the Millstone Grit. About ½ mile farther north there is another fault which throws off both the Coal-measures and the Millstone Grit, and brings the Limestone measures to the surface. At the western end of the Banknock coal-field the Hosie Limestone is found at the surface on the north side of the fault, and the outcrop of the Drumgray coal is found on the south side, thus representing a displacement of at least 300 fathoms, and proving that over 2500 feet of rocks have been carried away by the forces of denudation. The strip of Coal-measures let down between those faults is about 3½ miles long by ½ mile wide.

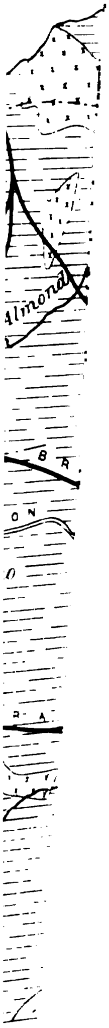
SECTION OF BANKNOCK AND CONEYPARK COAL-FIELD

		Fms.	Ft.	Ins.
From Geological Survey Memoir.	Upper Red Sandstone	6	0	0
	Coal	0	3	0
	Strata	23	0	0
	Coneypark Thick Coal (probably Pyotshaw)	1	1	0
	Strata	0	2	6
	Coneypark Main Coal (probably Main)	0	4	0
	Strata	7	3	0
	Coal	0	3	0
	Strata	5	0	0
	Foul Coal	0	4	6
	Strata	3	0	0
	Coal	0	3	6
	Strata	8	0	0
	Coal	0	1	6
	Strata	23	0	0
Section of Livingstone Pit, Banknock.	Coal	0	1	8
	Strata	7	3	0
	Virtuewell Coal (Five-quarter, Cockmalane)	0	3	3
	Strata	16	0	0
	Shale Coal { Carron Two-feet, Millar Coal of Falkirk, and (?) M'Neish Coal, Alloa }	0	2	0
	Strata	6	0	0
	Kiltongue Coal { Coal, Ft. 3, Ins. 6; Fireclay, Ft. 1, Ins. 6; Coal, Ft. 1, Ins. 6 } { Banknock Main Coal, Carron Craw Coal, or Carron Main Coal }	1	0	0
	Strata	2	0	0
	Bottom Coal	0	1	9
	Strata	3	0	0
	Upper Drumgray Coal	0	2	0
	Strata	8	0	0
	Jewel Coal	0	1	9
	Strata	10	0	0
	Lower Drumgray Coal	0	2	6
	Strata	10	0	0
	Soft Coal	0	2	0

Workings are at present being carried on in the Virtuewell Coal, the Shale Coal, and the five seams below the Kiltongue Coal. The Kiltongue Coal is practically exhausted, and also the Upper Seams.

In the Geological Survey Memoir (written in 1878) the following remark is made:—" Most of the seams have now been worked out, especially at the western end of the field, where they are most numerous and the basin narrowest. When these mining operations took place the value of oil shale was not recognized, for a rich shale which accompanied the Mussel-band Coal was left untouched during the removal of the coal. Its value, however, is now fully appreciated, and the shale is being taken out also."


Neck
Queensferry
FORTH BRIDGE
NORTH BRITISH RY
Neck
R. Almond
Uphall
Broxburn
NORTH BR
UNION
Ratho
LARGE FAULT WITH DOWNTHROW TO NORTH
Mid Calder
CALEDONIAN RA
Livingston
Kirknewton
120 FMS
W. Calder
Coal Measures
Millstone Grit
Carboniferous Limestone
Calciferous Sandstone
Old Red Sandstone
Whinstone, &c.
Faults
Dip of Strata



CHAPTER VIII

Linlithgowshire

Bo'ness Coal-Field.—The Bo'ness coal-field is divided into two sections by a zone of volcanic rocks, which forms a prominent feature of the landscape south of Linlithgow. These rocks are, with a few exceptions, not intrusive, but were formed by volcanic eruptions which occurred during the deposition of the Carboniferous Limestone series. They are composed of basalts and tuffs, which have been erupted as lava streams and showers of volcanic dust. These beds have thus been interstratified with sandstones, shales, and coal-seams, and have been faulted and upturned along with those seams. At the outcrops the hard basaltic lavas have resisted the denuding agencies to which the whole district has been subjected, and are now found as ridges of high ground rising in the Linlithgow Hills to several hundred feet above the surrounding country. Except near the shores of the Forth at Kinneil, and on Grange estate to the east, the volcanic rocks have not yet been pierced by shafts. There is a large area to the west of Linlithgow still undeveloped, but the prospect of finding workable coal here is not very encouraging.

At Bonnytoun, near Linlithgow, the coal-seams are found cropping out on the hillside, underneath the volcanic rocks, and have been worked for some distance under the hill by day mines. The seams are dipping towards the west at an inclination of 1 in 5. On the west of the hill they should therefore be met with at a depth of 100 to 150 fathoms. Farther west the rocks of the Limestone series are seen dipping underneath the Millstone Grit which underlies the Coal-measures of the Falkirk coal-field. As shown in the following section, the distance from the Castlecary Limestone at the base of the Millstone Grit to the Red Coal of Bo'ness is not less than 230 fathoms. The outcrop of the Castlecary Limestone can be traced from the shores of the Forth at Craigenbuck southward by the River Avon, and along the Slamannan and Bo'ness railway to Muiravonside and Bowden.

Along this tract the position of the Bo'ness coals will be found at a depth between 200 and 250 fathoms, and the thickness and value of the seams will no doubt lead to search being made for them here in the future. On the north the Bo'ness coal-field is bounded by the River Forth, but the coal-workings have already advanced for some considerable distance underneath the water. At Bridgeness the workings extend for about ⅓ mile beyond low-water mark. A detailed account of these workings is given by Mr. H. M. Cadell in the *Transactions of the Inst. of Mining Engineers*[1]. Mr. Cadell states that the bed of the Firth of Forth is here covered by a very hard stiff unstratified glacial "till" or Boulder Clay, full of ice-worn stones or boulders. On the top of the till there is a deposit of rich-brown or reddish plastic clay, 30 or 40 feet thick, finely laminated at places, and generally free of sand and stones, except at the upper and lower edges. It occurs on both shores of the firth, and extends for several miles along the coast. This stratum is of great importance to the miner, as it covers up the rock like a tight waterproof sheet, and prevents the sea from reaching the underlying strata. Being plastic, it can bend down when the rock subsides during the process of working the coal-seams below on the longwall system.

These beds of clay form such an impervious covering that the coal has at several places been worked underneath the Forth, right up to where it crops out against the boulder clay, and that without causing any flooding of the workings.

Towards the east the coal-seams crop out, and are succeeded regularly by the underlying Calciferous Sandstone series, and on to the south the coal-field disappears for some miles, the position of the seams being apparently entirely occupied by beds of volcanic rock.

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[1] Vol xiv, p. 237.

The following general section is compiled partly from observations of the Geological Survey, and partly from shafts and borings at Kinneil and Bridgeness. The volcanic zone is given as found at No. 18 pit, Kinneil, but the whinstones vary considerably in thickness in other parts of the district. For instance, a bore put down at Mains Distillery, near Linlithgow, went through successive beds of blue-green and red whin to the depth of 70 fathoms without meeting with any other kind of material, and it is the opinion of the geological surveyors that this bore penetrated only the upper part of the series.

GENERAL SECTION OF THE BO'NESS COAL-FIELD

		Fms.	Ft.	Ins.
	Craigenbuck or Castlecary Limestone	1	2	0
	Strata ... ... upwards of	50	0	0
	Dykeneuk or Calmy Limestone ...	1	1	0
	Strata ... ... more than	66	0	0
	Index Limestone	0	2	3
	Strata	22	0	0
	Splint Coal ... ... 2 ft. 4 ins. to	0	3	0
	Strata	8	0	0
	Corbiehall Coal ... ... 1 ft. to	0	3	0
	Strata	10	0	0
	Upper Ironstone and Seven-foot Coal	1	4	0
	Strata	9	0	0
Section of Volcanic Zone as found at No. 18 Pit, Kinneil Colliery.	Whinstone	4	0	0
	Coal	0	1	6
	Fireclay	0	0	6
	Whinstone	8	0	9
	Sandstone	0	2	8
	Blaes	0	1	4
	Coal	0	1	3
	Sandstone	6	4	0
	Blaes	0	0	9
	Wester Main Coal (with partings) ...	1	4	3
	Fireclay	0	0	1
	Whinstone	10	0	6
	Blaes	0	0	5
	Wandering Coal (with parting) ...	1	2	5
	Calmstone, hard white	0	5	2
	Whinstone, soft green	1	1	6
	Sandstone and Blaes	6	3	0
	Whinstone	1	3	0
	Black Fakey Blaes	1	3	0
	Whinstone	11	5	0
	Strata	2	5	3

			Fms.	Ft.	Ins.
	Red Coal	2 ft. 6 ins. to	0	3	0
	Strata		4	3	0
	Coal		0	1	4
	Strata		11	3	0
	Craw Coal		0	1	0
	Fireclay		0	0	3
Lower Ironstone	Parrot Coal		0	1	0
	Black-band Ironstone	0 to	0	0	3
	Light Fireclay (Maggie)		0	0	2
	Ironstone Band		0	0	4
	Soft Shale (holing)		0	0	3
	Strata		1	4	0
	Six-foot Coal (with partings)		1	0	0
	Strata		2	4	2
	Coal (Cannel and Common)		0	1	2
	Sandstone		0	3	3
	Coal (Cannel and Common)		0	1	2
	Sandstone		0	3	2
	Easter Main Coal	3 to	0	4	0
	Strata		12	0	0
	Smithy Coal		0	3	1
	Strata		2	3	0
	Carsey Coal		0	1	6

The Splint Coal, The Corbiehall Coal, and the Upper Ironstone crop out to the west of Bo'ness. They have been worked principally in the vicinity of the coast. Some workings have also been carried on farther inland, at Muirhouse, in a seam which probably corresponds with the Splint Coal, but for want of intermediate sections the position cannot be ascertained with certainty.

The Seven-foot Coal is being worked at Kinneil. A Black-band Ironstone, 1 foot 5 inches thick, known as the Upper Ironstone, was formerly worked along with this seam, but is not now worked. The Seven-foot Coal is about 4 feet 6 inches thick, with a band of stone 4 inches thick about the middle of the seam. It is a fairly good steam coal.

The Westermain Coal Seam was worked out many years ago in all the places where it existed at a moderate depth. At Kinneil its position is occupied by a seam of blaes. As this is the first important coal-seam that may be reached in any deep sinkings which are prosecuted to the west of Kinneil and Linlithgow, it is worth noting that it was very much sought after when the Bo'ness coal-field was first opened up. It seems to have been a profitable subject, but there is reason to believe it was only a local deposit. The roof was a sandstone post 6 or 7 fathoms thick. The whole seam was about 10 feet thick, but it contained three bands of dirt each about 1 foot thick. The thickness of coal and dirt appear to have been rather variable. At some points the coal has been split up into several distinct seams, and at others the dirt has dwindled down to only a few inches.

The Wandering Coal is, as its name implies, a very erratic seam. It is frequently found with trap both for roof and pavement, and the roof and pavement often come together, cutting out the whole of the coal. For that reason it cannot be looked upon as a profitable commercial subject.

The Red Coal is the first coal of the series underlying the volcanic zone, and is generally found from 3 to 6 fathoms below the whinstone. There is a bed of sandstone overlying the coal, and this forms a very good roof. The coal is of fair quality, and varies in thickness from 2 feet 6 inches to 3 feet.

The next coal shown in the section, 4½ fathoms below the Red Coal, has underneath it a seam of fireclay from 4 to 5 feet thick. The coal and fireclay have been worked together to a small extent, and the fireclay was used for brickmaking. There are no workings in this seam at present.

The Lower Ironstone, with its accompanying coal, has been extensively worked.

The section of the working is as follows:—

	Ft.	Ins.		Ft.	Ins.
Craw Coal	**0**	**9**	**to**	**1**	**1**
Clay, with Ironstone Nodules	**0**	**3**	**,,**	**0**	**3**
Cannel Coal	**0**	**8**	**,,**	**1**	**5**
Black-band Ironstone... ...	**0**	**3**	**,,**	**0**	**4**
Light Fireclay (Maggie) ...	**0**	**2**	**,,**	**0**	**10**
Ironstone Band	**0**	**4**			
Fireclay, holing	**0**	**3**			

At Kinneil Colliery the Black-band Ironstone is found as a foul parrot coal 6 inches thick.

The Craw Coal is a fairly good house and steam coal.

In some parts of the field the cannel coal is the most valuable portion of the seam, and the ironstone is only of secondary consideration; while in other places the ironstone is very valuable, and the cannel coal is thinner and of less value.

The Parrot and Ironstone are found in all the pits to the east and south of Bo'ness, and extend westward nearly as far as Kinneil. They have been worked out from the Schoolyard pit, in the middle of Bo'ness. At the Snab pit, 1 mile west of Bo'ness, the Ironstone and Parrot are not to be found, and there is only a thin coal occupying the position of the Main Coal. They have not been found in a workable state to the north-west side of Bonnytoun Hill. An analysis of the cannel coal by Mr. George R. Hislop is as follows[1]:—

Specific Gravity, 1.28.

			Per Cent.
Volatile Matters (containing 0.50 per cent of sulphur)			33.25
Coke	Carbon ...	59.67	66.55
	Sulphur ...	0.34	
	Ash	5.54	
Water, expelled at 212° Fahr.			1.20
			100.00

Gas per ton of coal at 60° Fahr., and barometer at 30 ins.	11,120 cub. ft.
Illuminating power of the gas in standard candles ...	30.15
Value of gas from 1 ton of coal in sperm	1149.49 lbs.

The iron furnaces at Kinneil and Bridgeness were established mainly for the smelting of an ironstone which occurred in this seam on the top of the Cannel Coal occupying the position of the Craw Coal, as shown on the foregoing section. The ironstone was 12 inches thick, and appears to have been of high quality. Unfortunately it was only found in a limited area in the vicinity of the ironworks, and when that area was exhausted the ironworks were abandoned.

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[1] *Trans. Inst. Min. Engineers*, vol. xiv, page 246.

The Six-foot Coal is itself of good quality, but contains several bands of dirt, which detract very much from its value.

The Easter Main Coal has been very extensively worked, and is now practically exhausted, except underneath the Forth and to the dip underneath the Millstone Grit, &c. It is of a very high quality, containing only 1.58 per cent of ash, and there are no bands of dirt or pyrites in the seam.

The Smithy Coal is not really a smithy coal, as its name would imply, but is a good coking coal about 3 feet thick. An analysis showed 62.37 per cent of fixed carbon and 3.10 per cent of ash. It is at present being worked by the Kinneil Coal Company in the deeper part of the field, but towards the outcrop at Bridgeness it is found to be thinner, and contains several partings of stone. It was, until recently, being worked by an open-cast mine below the trap of Bonnytoun Hill, 1¼ mile north-east of Linlithgow.

The Easter Main Coal was also worked at the same place, but the Red Coal is mostly destroyed by the overlying trap.

The Carsey Coal outcrop is indicated on the Ordnance Survey Geological maps, but it has never been worked in the district.

The following description of the southern portion of the Carboniferous Limestone measures of Linlithgowshire is taken from a paper read before the Institute of Mining Engineers by Mr. H. M. Cadell,[1] and reproduced by permission of the Council of the Inst. of Mining Engineers:—

"All the Bo'ness coal-seams deteriorate in quality and diminish in thickness as they are traced southwards towards the volcanic area at Linlithgow,. and the southern limit of the productive coal-field is not much more than 1½ mile distant from the coast. . . .

"To the west of Linlithgow, at Little Mill, on the river

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[1] *Trans.*, vol. xxii, p. 372.

Avon, a deep boring was made in 1872 in a bed of tuff or volcanic ash, whose surface was a few feet below the Index Limestone, in the hope of reaching the Upper Coal Seams of Bo'ness. The bore-hole passed through 602 feet of this ash, with hardly any non-volcanic strata, and after penetrating 42 feet of blaes, &c., lying on 34 more feet of volcanic rock, below which was 2½ feet of argillaceous strata, the boring was suspended at a depth of 691 feet without reaching anything of a coaly nature.

"This bore-hole, and others which have been drilled near it, show that the position of the Upper Coal Seams of Bo'ness and their associated strata is occupied by a mass of purely volcanic material in the vicinity of Linlithgow. The boring was not carried deep enough to reach the position of the lower seams, but other evidence tends to show that they too were probably never formed, or at least are of no commercial value, in this district.

"The Carboniferous Limestone series, immediately south of Linlithgow, appears to be almost entirely composed of volcanic rocks, chiefly amygdaloidal basalts and occasional ash-beds, which have accumulated to a depth of more than 2000 feet and can be seen resting on the Hurlet Limestone at Hillhouse, and terminating a short distance below the Dykeneuk or Calmy Limestone near the top of the whole series. The writer believes that the Bo'ness coal-seams were never formed across this tract of volcanic ground, which probably remained as an island in the Carboniferous sea during the greater part of the Limestone period.

"The Bathgate coal-seams, which come on to the south, are thus probably unconnected with those of the northern or Bo'ness coal-field.

"South of Linlithgow the lower limestones are unusually thick, and were formerly mined along a line of quarries extending southwards to the vicinity of Bathgate, but these workings have all been closed for half a century or more, and limestone-quarrying in the Bathgate Hills is now practically abandoned. . . .

"At Kipps the Bathgate coal-seams begin to appear, and one was worked at a small colliery more than two centuries ago, and again for a short time in 1846, but it has long ago been abandoned, in consequence of the number of faults intersecting the coal.

"The coal-seam in the north mine was 33 inches thick with 3 inches of parrot below, but every few feet a fault or dyke was found to intersect it, so as to render the little coal-field quite unworkable.

"At Hilderston Hills, 1½ mile south of Kipps, we find the coal under the Index limestone reappearing in increased dimensions. A small colliery was carried on here for many years, but the coal was not of the best quality, and the field was abandoned. A report made on this colliery by the late Dr. David Landale, in 1853, gives the following section of seams in the pit, which was 300 feet deep, to the Parrot Coal:—

Description of Strata.	Thickness of Strata. Ft.	Ins.
Red Coal Seam, with Dirt Rib in middle	1	9
Strata	36	0
Black Coal Seam	1	8
Strata	42	0
Two-foot Coal Seam	1	4
Strata ... . 4 ft. to	10	0
Fiddle Coal Seam	4	10
Strata	24	0
Parrot Coal Seam, including Stone Ribs	6	0
Strata	42	0
Main Coal Seam, with Stone Ribs ...	3	0

"The following is a section of the Parrot Coal Seam:—

	Ft.	Ins.	Ft.	Ins.
Roof: Coal and Stone in alternate layers			1	6
Coal	0	10		
Stone	0	1½		
Coal	0	1½		
Stone	0	7		
Coal	0	5		
Stone	0	1		
Coal, free	1	4		
Stone	0	1½		
Coal	0	6		
Parrot Coal	1	0		
Pavement: Sandstone				
	5	1½		

"The following is a section of the Main Coal Seam:—

	Ft.	Ins.
Roof: Fakes		
Coal and Stone, mixed	0	8
Stone	0	5
Coal, irregular	0	6
Stone	0	7
Coal	1	3
	3	5

"From these sections it is clear that the coal-seams at best are not of great value, on account of the dirt and stone associated with them.

"A diamond boring was made, in 1900, to the west of Hilderston Farm to test the beds to the dip of the coal-field, and the following is an abstract of the section then disclosed:—

SECTION OF BORE-HOLE AT HILDERSTON FARM

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1.	Surface, Whin Boulders	54	0	54	0
2.	Sandstone	1	5	55	5
3.	Fireclay, &c.... ...	20	9	76	2
4.	Fakes...	1	0	77	2
5.	Levenseat Limestone	4	2	81	4
6.	Blaes, Fakes, and Sandstone... ...	13	9	95	1
7.	Coal	0	6	95	7
8.	Sandstone	7	4	102	11
9.	Blaes and Fakes ...	16	1	119	0
10.	Sandstone	55	2	174	2
11.	Blaes and Ironstone Balls	39	1	213	3
12.	Lime and Blaes ...	7	6	220	9
13.	Calmy Limestone ...	1	6	222	3
14.	Blaes	0	4	222	7
15.	Coal	0	4	222	11
16.	Light Fireclay ...	3	6	226	5
17.	Limestone, hard ...	0	9	227	2
18.	Fireclay and Fakes...	4	6	231	8
19.	Limestone	0	5	232	1
20.	Light Fireclay ...	3	5	235	6
21.	Bands of Sandstone, Blaes and Fakes ...	51	10	287	4
22.	Green Whin, in hard and soft beds ...	136	9	424	1
23.	Fakes and Blaes ...	14	3	438	4
24.	Fakey Fireclay ...	1	0	439	4
25.	Coal	0	2	439	6
26.	Fireclay and Fakes ...	7	5	446	11
27.	Fakes and Sandstone	14	0	460	11
28.	Blaes	0	4	461	3
29.	Coal, Parrot ...	0	4	461	7
30.	Coaly Blaes	0	8	462	3
31.	Coal	0	4	462	7
32.	Fakes and Balls ...	17	11	480	6
33.	Blaes	1	3	481	9
34.	Limestone	0	9	482	6
35.	Fakes, with Blaes and Lime	13	1	495	7
36.	Blaes and Balls ...	23	8	519	3
37.	Index Limestone ...	4	11	524	2
38.	Blaes and Balls ...	4	7	528	9
39.	Light Fireclay and Ironstone Balls ...	9	9	538	6
40.	Fakes...	2	0	540	6
41.	Sandstone	41	2	581	8
42.	Fakes...	18	0	599	8
	Balbardie Coal Seam. Ft. In.				
43.	Coal 1 4				
44.	Coal, Parrot... 0 3				
		1	7	601	3

No.	Description of Strata.	Thickness of Strata.		Depth from Surface.	
		Ft.	In.	Ft.	In.
45.	Fakes and Sandstone	3	1	604	4
46.	Fakes, Fireclay and Balls	12	8	617	0
47.	Blaes, with thin Coal Ribs	4	5	621	5
48.	Fireclay	0	10	622	3
49.	Fakes and Blaes ...	9	4	631	7
50.	Light Fakey Clay and Balls	7	2	638	9
51.	Fireclay and Blaes ...	0	6	639	3
52.	Coal, foul	1	3	640	6
53.	Fakes and Blaes ...	4	9	645	3
54.	Coal, foul	1	10	647	1
55.	Coaly Fireclay and Balls	0	5	647	6
56.	Ash, conglomerate ...	30	5	677	11
57.	Limey Fakes ...	27	1	705	0
58.	Limey Fakes or Ash	74	4	779	4
59.	Fakes and Coal Ribs	5	3	784	7
60.	Fakey Sandstone ...	12	3	796	10
61.	Gray Fakes	1	9	798	7

"In the foregoing section it will be observed that the three upper bands of limestone were found in their normal positions, and the bore-hole passed through the Balbardie Coal Seam below the Index Limestone. The other thin coal-beds no doubt represent the seams in the adjacent pit, the upper part of which passes through the Index Limestone. It is not uncommon in boring through a soft coal-seam to find that part of it has been worn away, and the actual thickness greater than the borer's record shows. The bore-hole apparently passed through the coal-bearing strata and entered the top of the thick volcanic series below.

"The thickness of underlying volcanic rock is probably not less than 900 feet at this part of the field, and the coal-bearing section at the top not more than 150 feet.

"At the base of this zone of trap-rocks lies the Great limestone formerly quarried on a large scale at the Silvermine, so named from a small vein of argentiferous galena that traverses the limestone, and was mined in the reign of King James VI, over 300 years ago.

"The section in this and other quarries farther south varies considerably. In the North Silvermine quarry the limestone, when worked a century ago, was, according to Mr. James Bald, 25 feet thick, with 2½ feet of coarse rock below it. In the South Silvermine quarry the section given by Mr. Forsyth is as follows:—

No.	Description of Strata.			Thickness of Strata.		Depth from Surface.	
		Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
1.	Clay			7	0	7	0
2.	Shale, Blaes			7	0	14	0
3.	Slatey Sandstone			10	0	24	0
4.	Shale			30	0	54	0
5.	Freestone			8	0	62	0
6.	Fireclay			3	0	65	0
7.	Limestone	8	0	39	0	104	0
8.	Limestone, with Balls of Flint	2	6				
9.	Limestone	8	0				
10.	Limestone, red	3	6				
11.	Limestone, brittle	3	0				
12.	Limestone	2	6				
13.	Limestone, very good	11	6				

"Under the limestone Mr. Bald states there are 18 feet of inferior rock, making the total thickness 58 feet.

"The volcanic rocks come on immediately above the shale at the top of the quarry, and the limestone rests on an ash-bed not many feet above another massive basaltic lava-flow, probably about 500 feet thick. This lower trap rests in turn on a lower bed of limestone apparently representing the Hurlet seam, situated here some 1700 feet below the Index Limestone.

"As we follow the outcrop 1 mile or so southward towards Balbardie and Ballencrieff, the volcanic rocks diminish in thickness, and the coal-seams increase in quality and number. The higher part of the section has been well opened up in boring and in the extensive workings of the Balbardie Colliery, and its main features are therefore well known.

"The Ballencrieff Colliery, to the north of Bathgate, has been worked from an early date along the outcrop of the coal-seams. The section in the engine or pumping pit, on the high ground, 1 mile north of the town, which was in operation a century ago, was described as follows:—

No.	Description of Strata.			Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
1.	Surface and Strata			102	0	102	0
2.	Coal, the Red Coal Cubic			1	11	103	11
3.	Strata			48	0	151	11
4.	Coal, the Two-foot Coal Cubic			2	0	153	11
5.	Strata			30	0	183	11
6.	Coal, parrot ...	1 ft. 0 ins.	Parrot Coal Seam.	4	6	188	5
7.	Stone	0 ft. 9 ins.					
8.	Coal, cubic ...	2 ft. 9 ins.					
9.	Strata			66	0	254	5
10.	Coal, upper band	1 ft. 4 ins.	Main Coal Seam.	5	2	259	7
11.	Stone	0 ft. 6 ins.					
12.	Coal, mid ...	1 ft. 0 ins.					
13.	Stone	0 ft. 6 ins.					
14.	Coal, lower band	1 ft. 10 ins.					

"The upper workable seams are now exhausted at Ballencrieff, and the deeper part of the coal-field to the west is being worked from the new shaft of the Balbardie Colliery, which is 1032 feet to the pavement of the Balbardie Gas Coal Seam. The strata here dip westward at an average angle of 12 degrees. The upper part of the shaft is in the Millstone Grit, and as the details of the higher strata are not of great importance, it may be of sufficient interest to record here only the general nature of the section above the Index limestone, as found in a borehole by Mr. Wood near the site of the shaft, and the full section below that horizon, the details of which Mr. Thom (the manager) has kindly given to the writer.

SECTION AT BALBARDIE COLLIERY

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth of Strata. Ft.	In.
1.	Surface and Millstone Grit to Levenseat Limestone, 4½ ft. thick	338	7	338	7
2.	Levenseat to Calmy Limestone, 4 ft. thick	162	0	500	7
3.	Strata	90	0	590	7
4.	Balbardie Whinstone Bed	115	0	705	7
5.	Strata	225	0	930	7
6.	Sandstone	26	3	956	10
7.	Blaes	23	3	980	1
8.	Index Limestone ...	4	0	984	1
9.	Blaes, soft	4	3	988	4
10.	Coal	0	6	988	10
11.	Whinstone	35	0	1023	10
12.	Sandy Fireclay ...	4	4	1028	2
	Balbardie Gas Coal Seam.	Ft.	In.		
13.	Wild Gas Coal	0	3		
14.	Cannel Coal	0	7		

No.	Description of Strata.			Thickness of Strata.		Depth of Strata.	
				Ft.	In.	Ft.	In.
15.	Ironstone ...	0	3				
16.	Fireclay ...	1	10				
17.	Free Coal ...	1	6				
		——		4	5	1032	7
18.	Fireclay			0	5	1033	0
19.	Sandstone, gray ...			4	3	1037	3
20.	Fakes			5	6	1042	9
21.	Blaes			1	4	1044	1
	China or Shaly Coal Seam.						
		Ft.	In.				
22.	Coal	1	1				
23.	Blaes Band ...	0	11				
24.	Wild Cannel Coal ...	0	6				
25.	Coal	0	5				
		——		2	11	1047	0
26.	Fakes			1	4	1048	4
27.	Sandstone			6	0	1054	4
28.	Rocky Plies ...			3	9	1058	1
29.	Fakes			0	9	1058	10
30.	Blaes			0	3	1059	1
31.	Rocky Plies ...			2	0	1061	1
32.	Fakey Blaes ...			1	11	1063	0
33.	Ironstone			0	1	1063	1
34.	Blaes			0	2	1063	3
35.	Cement Bed ...			1	0	1064	3
36.	Coal			0	4	1064	7
37.	Blaes, soft			0	8	1065	3
38.	Sandstone			0	4	1065	7
39.	Fakes			0	4	1065	11
40.	Coaly Parting ...			0	1	1066	0
41.	Fakes			0	5	1066	5
42.	Sandstone, gray ...			4	11	1071	4
43.	Fakes			2	11	1074	3
44.	Blaes			1	9	1076	0
45.	Coal			0	1	1076	1
46.	Sandy Fakes, hard			20	9	1096	10
47.	Blaes			2	11	1099	9
48.	Fakes			3	7	1103	4
49.	Sandstone, gray ...			5	9	1109	1
50.	Blaes			1	7	1110	8
51.	Coal			0	6	1111	2
52.	Fakes			7	1	1118	3
53.	Sandstone			5	9	1124	0
54.	Blaes			0	10	1124	10
55.	Coal			0	2	1125	0
56.	Fireclay			0	1	1125	1
57.	Coal			0	2	1125	3
58.	Blaes, hard			0	2	1125	5
59.	Coal			1	9	1127	2
60.	Fireclay			0	2	1127	4
61.	Rocky Plies ...			3	2	1130	6
62.	Hard Sandstone, white			1	9	1132	3
63.	Fakes			0	10	1133	1
64.	Blaes			3	2	1136	3
65.	Coal			1	4	1137	7
66.	Fireclay			0	7	1138	2
67.	Fakes			2	1	1140	3
68.	Blaes			5	3	1145	6
69.	Fakes			4	0	1149	6
70.	Coal			0	4	1149	10
71.	Blaes			0	2	1150	0
72.	Sandstone			2	0	1152	0
	Jewel Coal Seam.						
		Ft.	In.				
73.	Coal	0	3				
74.	Blaes Rib ...	0	3				
75.	Coal	2	8				
		——		3	2	1155	2
76.	Fakes, dark ...			1	7	1156	9
77.	Sandstone, white ...			1	3	1158	0
78.	Blaes			4	0	1162	0
79.	Coal			0	3	1162	3
80.	Fireclay			0	2	1162	5
81.	Fakes			3	6	1165	11
82.	Blaes			1	0	1166	11
83.	Coal			0	6	1167	5
84.	Fireclay			0	9	1168	2
85.	Fakes			11	3	1179	5
86.	Craw Coal, foul ...			1	8	1181	1
87.	Rocky Plies ...			7	5	1188	6
88.	Blaes			2	0	1190	6
	Main Coal Seam.						
		Ft.	In.				
89.	Coal	0	7				
90.	Fireclay ...	0	3				
91.	Coal	1	4				
92.	Blaes, coaly	0	3				
93.	Coal	0	8				
94.	Fireclay Rib	0	2				
95.	Coal	1	6				
96.	Cement Rib	0	2				
97.	Coal	1	0				
		——		5	11	1196	5

“The principal seam worked at the Balbardie Colliery is the cannel coal which although thin is shown by the following analysis to be of high value as a gas producer:—

Volatile Constituents—		
Gas, Tar, &c.	49.20	51.14
Sulphur	0.36	
Water, at 212° Fahr.	1.58	
Non-Volatile Constituents—		
Carbon	42.96	48.86
Sulphur	0.17	
Ash	5.73	

"One ton produces 14,150 cubic feet of gas of 36 candle-power, and 1094 pounds of coke of fair quality.

"The portion of the Balbardie section below the Main Coal Seam is only approximately known from surface measurements. The Great Limestone of Petershill, corresponding to that of Silvermine and Sunnyside quarries farther north, is about 60 feet thick, with beds of volcanic rock above and below, as indicated on the drawing, which also shows the lower limestone formerly quarried at Kirkton, at the base.

"The strike of the strata in the Balbardie Colliery, west of Bathgate, is regular, but as we move southwards into the Boghead and Durhamtoun district, a powerful fault—the so-called Heatherfield dyke—is crossed, which has a downthrow to the south and several branches, and interrupts the continuity of the strata between the two coal-fields.

"In the Durhamtoun area, about 1 mile south of Bathgate, a deep boring was made some years ago by Mr. Ronald Johnstone from the outcrop of the Boghead or Torbanehill mineral (which is taken as the local base of the Coal-measures) down to the position of the Index Limestone, and we are thus enabled to measure accurately the thickness of the Millstone Grit series. The Index Limestone appears to have been replaced by whinstone in this bore-hole, but the record of another deep boring made by Mr. Henry Walker, 2100 feet farther east, near the Boghead Pit, supplies the part of the section from the Calmy to the Index Limestone. The lower part of the section showing the depth and thickness of the workable seams in this shaft, which is 900 feet deep, to the Main Coal Seam, has been kindly supplied by the manager of the colliery.

SECTION AT BOGHEAD FROM THE BASE OF THE COAL-MEASURES

No.	Description of Strata.	Thickness of Strata.		Depth from Surface.	
		Ft.	In.	Ft.	In.
1.	Coal, 2 ft. 9 ins. (base of Coal-measures)				
2.	White Sandy Shale or Blaes	2	9	2	9
3.	Red and White Sandstone	5	0	7	9
4.	Light-blue Shale or Blaes	6	6	14	3
5.	Bastard Gray Sandstone	1	0	15	3
6.	Dark-gray Shale, with hard beds of Sandstone	9	5	24	8
7.	Gray Sandstone ...	8	10	33	6
8.	Mottled Shale ...	4	6	37	0
9.	Gray Sandstone, and Ribs of Shale ...	30	6	68	6
10.	Blue Shale	2	0	70	6
11.	Gray Sandstone and Red Ironstone Balls	8	8	79	2
12.	Blue Shale	1	0	80	2
13.	Gray and Red Sand	10	2	90	4
14.	Gray and Blue Shale and Sand Rib ...	17	5	107	9
15.	Gray Sandstone ...	5	6	113	3
16.	Reddish-blue Shale...	4	6	117	9
17.	Gray Sandstone with red spots	13	7	131	4
18.	Light-blue Shale ...	7	6	138	10
19.	Spongy Sandstone ...	19	6	158	4
20.	Brown Shale... ...	0	6	158	10
21.	White and Brown Sandstone ...	9	9	168	7
22.	Mottled Shale lying on Gray Sandy Shale	5	9	174	4
23.	Red Ironstone ...	0	6	174	10
24.	Gray Shale	0	10	175	8
25.	Gray Sandstone ...	3	0	178	8
26.	Gray and Black Shale	7	1	185	9
27.	Gray Sandstone with Shale Joints ...	43	7	229	4
28.	Gray and Black Shale	38	11	268	3
29.	Light-gray Sandstone	16	0	284	3
30.	Bands of Shale and Sandstone ...	10	0	294	3
31.	Gray Shale Bands ...	10	4	304	7
32.	Sandstone and Shale Ribs	12	0	316	7
33.	Black Shale	5	10	322	5
34.	Gray Sandstone ...	6	0	328	5
35.	Black Shale	1	8	330	1
36.	Gray Sandstone ...	6	9	336	10
37.	Black Shale	1	8	338	6
	BASE OF MILLSTONE GRIT				
38.	Levenseat Limestone	7	1	7	1
39.	Blue Shale	5	0	12	1
40.	Gray Sandstone ...	6	3	18	4
41.	Black and Brown Shale	6	0	24	4
42.	Gray Sandstone ...	2	9	27	1
43.	Gray Sandy Shale ...	1	3	28	4
44.	Gray Sandstone with red spots	29	3	57	7
45.	Black and Gray Shale, sandy below ...	37	9	95	4
46.	Gray Sandstone ...	9	9	105	1
47.	Gray Sandstone with small Coal-beds ...	1	0	106	1
48.	Blue Sandy and Black Shale and Sandy Ribs	14	10	120	11
49.	Gray Sandstone ...	4	6	125	5
50.	Gray Sandy Shale and Sand Rib in centre	8	0	133	5
51.	Gray Sandstone ...	8	6	141	11
52.	Gray, Sandy, and Black Shale ...	19	0	160	11
53.	Gray Sandstone ...	17	2	178	1
54.	Gray and Blue Sandy Shale	31	9	209	10
55.	Black Shale Blaes ...	44	9	254	7
56.	Calmy Limestone	4	2	258	9
57.	Sandstone	11	8	270	5

No.	Description of Strata.			Thickness of Strata.		Depth from Surface.	
				Ft.	In.	Ft.	In.
58.	Gray Fakes, Sandstone Rib at top ...			14	10	285	3
59.	Sandstone			7	3	292	6
60.	Kinglestone ...			1	5	293	11
61.	Gray Fakes and Hard Ribs ...			26	8	320	7
62.	Sandstone			11	4	331	11
63.	Fakes and Hard Ribs			17	10	349	9
64.	Sandstone and Fakes			6	7	356	4
65.	Dark-gray Fakes ...			6	0	362	4
66.	Whinstone, soft above			36	6	398	10
67.	Dark-gray Fakes ...			4	8	403	6
68.	Whinstone			40	1	443	7
69.	Dark Fakes ...			2	4	445	11
70.	Coal, foul			0	4	446	3
71.	Bands of Sandstone, Fakes and Blaes			81	6	527	9
72.	Blue Blaes			19	0	546	9
73.	Index Limestone ...			4	4	551	1
74.	Blaes			8	7	559	8
75.	Fireclay			4	4	564	0
76.	Sandstone and Fakes			7	7	571	7
77.	Sandstone			14	9	586	4
	Balbardie Parrot Coal Seam.	Ft.	In.				
78.	Blaes ...	2	6				
79.	Gas Coal ...	0	8				
80.	Ironstone ...	0	4				
81.	Fireclay ...	0	4				
82.	Blaes ...	0	6				
83.	Sandstone ...	0	4				
84.	Blaes ...	0	6				
85.	Coal	1	6				
86.	Fireclay ...	0	2				
				6	10	593	2
87.	Strata			15	8	608	10
	Shaly Coal Seam.						
88.	Coal	1	4				
89.	Wild or Inferior Gas Coal ...	0	8				
90.	Good Gas Coal	0	4				
				2	4	611	2
91.	Strata			98	5	709	7
	Jewel Coal Seam.						
92.	Coal	0	3				
93.	Wild Gas Coal	0	4				
94.	Coal	3	0				
				3	7	713	2
95.	Strata			52	10	766	0
	Main Coal Seam.						
96.	Coal	1	6				
97.	Dirt	0	1				
98.	Coal	1	1				
99.	Dirt	0	3				
100.	Coal	1	5				
101.	Dirt	0	1				
102.	Coal	1	5				
103.	Dirt	0	3				
104.	Coal	1	1				
				7	2	773	2

"In the Boghead and Durhamtoun section it will be observed that the volcanic rocks are dwindling away to the south, and the sedimentary beds are thickening out as we recede from the Bathgate Hills. The Balbardie trap-bed above the Index Limestone, which is traceable all the way from Hilderston Hills, where it is 136 feet thick, and represents the last of the volcanic eruptions of the Carboniferous Limestone age, is only 115 feet thick at Ballencrieff. It splits up into two parts here, whose joint thickness is 76½ feet, disappearing altogether a short distance farther south.

"The last section to which the writer wishes to refer is that in the Foulshiels and Blackburn district to the west of

Addiewell, near the southern boundary of Linlithgowshire. The Balbardie Gas Coal, though represented, is not of value here, and the Main and Jewel Coal Seams are the chief workable seams. The Main Coal Seam runs into Lanarkshire, and is extensively worked at Wilsontown, a few miles farther south. The general strike of the strata is from north to south, and the dip westward about 20 degrees. The outcrops are fairly straight and regular, and are only interrupted by cross-faults at a few places.

"It will be noticed that as the volcanic rocks diminish the coal-seams increase in number, but they never approach, either in number or value, the excellent seams of the Bo'ness coal-field.

"The following section of a boring made in 1898 on Mosshall estate, near Foulshiels, which Messrs. Robert Forrester & Co., the colliery owners, have been good enough to give the writer, shows the character of the coal-bearing section below the Index Limestone in this part of the county.

No.	Description of Strata.			Thickness of Strata.		Depth of Strata.	
				Ft.	In.	Ft.	In.
1.	Surface Clay and Stones			35	0	35	0
2.	Brownish Sandstone...			5	6	40	6
3.	Blue Blaes and Balls			33	4	73	10
4.	Limey Fakes ...			1	10	75	8
5.	Index Limestone ...			4	0	79	8
6.	Gray Blaes			8	0	87	8
7.	Coal			0	10	88	6
8.	Fireclay			0	11	89	5
9.	Gray Fakes and Fireclay			6	3	95	8
10.	Light Sandstone ...			3	9	99	5
11.	Gray Blaes			0	5	99	10
12.	Light Sandstone ...			4	11	104	9
13.	Gray Fakey Fireclay			0	11	105	8
14.	Dark Blaes and Balls			0	11	106	7
	Representative of the Balbardie Parrot Seam.	Ft.	In.				
15.	Coal	1	8				
16.	Coal, soft ...	0	2				
17.	Coal, firmer ...	0	2				
	——			2	0	108	7
18.	Gray Fakey Sandstone			7	1	115	8
19.	Dark Blaes			0	6	116	2
	Balbardie Shaly or China Coal Seam.	Ft.	In.				
20.	Coal	2	8				
21.	Coal, soft ...	0	2				
	——			2	10	119	0
22.	Dark Fireclay ...			0	6	119	8
23.	Gray Fakes			1	9	121	3
24.	Fakes and Sandstone			13	10	135	1
25.	Dark Blaes			3	4	138	5
26.	Light Sandstone ...			3	9	142	2
27.	Gray Fakes			3	10	146	0
28.	Fakes and Sandstone			12	3	158	3
29.	Light Sandstone ...			12	0	170	3
30.	Coaly Fireclay ...			1	6	171	9
31.	Light Fireclay ...			1	4	173	1
32.	Fakey Fireclay ...			5	6	178	7
33.	Fakes and Sandstone			23	2	201	9
34.	Dark Fakey Blaes ...			5	0	206	9
35.	Coal, soft			0	10	207	7
36.	Dark Blaes			0	4	207	11

No.	Description of Strata.			Thickness of Strata.		Depth of Strata.	
				Ft.	In.	Ft.	In.
37.	Fakes and Sandstone			3	0	210	11
38.	Black Blaes			1	6	212	5
39.	Coal			2	6	214	11
40.	Fireclay			0	2	215	1
41.	Fakey Sandstone			4	6	219	7
42.	Dark Blaes			1	4	220	11
43.	Coaly Blaes			1	3	222	2
44.	Dark Fakey Blaes			3	2	225	4
45.	Gray Sandy Fakes			6	0	231	4
46.	Fakey Sandstone			6	7	239	11
47.	Fakes, with hard Sandstone Ribs			32	0	271	11
48.	Dark Blaes			1	0	272	11
	Jewel Coal Seam.	Ft.	In.				
49.	Coal	0	8				
50.	Fireclay	0	10				
51.	Coal	3	11				
		—		5	5	278	4
52.	Gray Fakes			0	3	278	7
53.	Gray Sandy Fakes			3	5	282	0
54.	Light Sandstone			6	11	288	11
55.	Gray Fakey Sandstone			3	6	292	5
56.	Black Fakes			2	0	294	5
57.	Light Sandstone			8	3	302	8
58.	Gray Fakey Sandstone			3	2	305	10
59.	Gray Fakey Blaes			1	1	306	11
60.	Coal			0	9	307	8
61.	Fireclay			0	6	308	2
62.	Blaes, with Coal			1	4	309	6
63.	Dark Blaestone			0	10	310	4
64.	Gray Fakes			1	4	311	8
65.	Gray Sandstone			6	4	318	0
66.	Dark Blaes			1	6	319	6
67.	Coal			1	6	321	0
68.	Coal—Rib			0	1	321	1
69.	Fireclay			0	9	321	10
70.	Gray Fakey Sandstone			19	10	341	8
71.	Blaes			0	1	341	9
	Main Coal Seam.	Ft.	In.				
72.	Coal	1	1				
73.	Blaes	0	2				
74.	Coal	2	10				
75.	Fakey Fireclay	0	5				
76.	Coal	1	7				
		—		6	1	347	10
77.	Black Blaes			0	2	348	0

"Only one bed of eruptive rock (the so-called 'lakestone' of Blackburn) reaches so far south in this part of the Carboniferous Limestone series. It is geologically described as a pikrite, and has an extremely beautiful and interesting microscopic structure. It is interesting economically as a rock that (although it soon crumbles down when exposed to the weather) has great capacity for resisting heat, and has long been quarried to provide soles for bake-ovens, where high temperatures are prevailing.

"Near the base of the series, several beds of limestone, associated with seams of inferior coal occur to the south and west of Blackburn, but none of the latter are now worked. The thickness of the lower part of the section, from the Main Coal Seam to the Hurlet Limestone, is apparently about 1100 feet, and this includes a seam of gas coal 140 feet below the Main Seam, as well as the beds of coal formerly worked, near the Hosie Limestone, 200 feet above the Hurlet horizon. The best coal is, however, found in the upper part of the section extending from the Index horizon downwards for 290 or 300 feet to the Main Coal Seam."

To the south of the district thus described by Mr. Cadell the coal-seams are being worked at Loganlea and Woodmuir, on the Caledonian Railway. The section at the Woodmuir pits is as below:—

	Fms.	Ft.	Ins.
Strata	33	0	0
Woodmuir Main Coal ...	0	2	5
Strata	27	0	0
Smithy Coal	0	2	4
Strata	4	0	0
Lady Morton Coal	0	3	4
Strata	uncertain		
Wilsontown Main Coal ...	uncertain		

At Loganlea the Wilsontown Main Coal is 4 feet 6 inches thick, with a band of dirt about 7 inches thick near the centre. On the south side of the railway this parting becomes much thicker. In a shaft sunk a few years ago on Woodmuir estate it was found 22 feet thick. The Wilsontown Main Coal was thus split up into two separate seams, as in the following section:—

	Ft.	Ins.
Coal	1	6
Strata	22	0
Coal	1	7
Stone	0	3
Coal	0	8

The Lady Morton Coal Seam appears to be a local deposit. It may correspond with the coal marked No. 67 in the section of Mosshall given above. At Woodmuir the section of the seam is:

	Ft.	Ins.
Coaly Blaes	0	10
Coal	1	0
Fireclay	0	10
Coal	2	4

Both this seam and the Woodmuir Main Coal Seam are of fairly good quality for house or steam purposes.

The Smithy Coal is used both for coking and for smithy purposes.

ARMADALE DISTRICT.—The coal seams of the Upper Coal-measures, as found in the Armadale district, are all of second-class quality, and the fact that they have been so extensively worked is mainly accounted for by the presence of the famous Torbanehill Cannel Coal. The value of this coal was an inducement to sink pits, which have since been used for working the other seams. At the same time as the Torbanehill mineral was being worked, a seam of coal-shale known locally as the Upper Cannel was also worked as an oil-producer. The position of the Upper Cannel in the section seems to correspond either with that of the Shotts Gas Coal or the Clefted Coal. It is about thirty years since the workings in this upper seam were abandoned, but the recent increase in the value of oil shales offers some prospect of its being reopened. A practical test made this year (1901) gave the following results from this seam, as found in one of the shafts at Bathville Colliery:—

Crude Oil (Specific Gravity, .956)	29.70 galls. per ton.
Sulphate of Ammonia	34.48 lbs. ,,

The other seams of the district are shown in the following section:—

SECTION OF ARMADALE COAL-FIELD

		Fms.	Ft.	Ins.
Upper Cannel Coal ...	2 ft. to	0	4	0
Strata		6	0	0
Mill Coal		0	1	10
Strata		9	0	0
Ball Coal and Ironstone		0	2	6
Strata	2 fms. to	7	0	0
Main Coal		0	3	10
Strata		10	0	0
Colinburn Coal		0	2	9
Strata	1 fm. to	2	0	0
Torbanehill Gas Coal and Ironstone.				

The Mill Coal is the best coal in the series, and makes a second-class house coal or a fair steam coal. The roof is blaes, 6 feet thick, with rock above. The holing is in the coal.

The Ball Coal is of very secondary quality, but is quite suitable for the oilworks in the adjoining district. The principal value of this seam lies in the ironstone which overlies it. The ironstone is very erratic, thickening out often in a few yards from 2 inches to about 3 feet, and occasionally it has been found as much as 7 feet thick.

The Main Coal has the following section:—

		Ft.	Ins.
Sandstone	... ...	1	6
Fireclay	... ... 0 to	4	0
Coal	... ...	1	9
Parting	... ...	0	1
Coal	... ...	2	0
Daugh holing	... 4 ins. to	1	0

The Colinburn Coal is from 2 feet 6 inches to 3 feet thick, of second-class quality, with a fair blaes roof. Underneath the coal there are 2 to 3 feet of fireclay. This fireclay makes a high-class refractory firebrick, and is extensively manufactured at the Bathville Brickworks. At a distance varying from 6 to 12 feet below the Colinburn Coal is found the Torbanehill Gas Coal.

At present the gas coal is being worked at Colinshiels pit, where it has the following section:—

		Ft.	Ins.
Fireclay	... ...	4	6
Cement	... ...	0	2
Gas Coal	... ...	0	4
Fireclay	... ...	1	0

A new shaft has also been sunk recently on Torbanehill estate to open up some patches of the gas coal.

In working the Colinburn Coal it is customary to put down bore-holes to the Gas Coal position, and wherever an area is found exceeding 3 inches in thickness, a mine is driven down to work it out. In this way the cost of exploration is very much reduced. Very little of the Torbanehill Gas Coal is now left to work, but as considerable interest attaches to the past working of this seam, I give here some notes from a paper read in 1861 before the

Royal Scottish Society of Arts by the late John J. Landale, mining engineer.

"The Boghead Gas Coal, and the Slatey-band Ironstone has been most earnestly and indefatigably searched after by many parties, and the position is thoroughly determined and admitted in the mining world. It is, however, a most erratic deposit, occurring only in small patches, and islands, and these vary much in thickness and quality. . . .

"This gas coal, like most of the other first-class cannels, has the peculiarity of thickening and thinning at different places, sometimes gradually tapering off to a half, a third, a fourth, and not infrequently disappearing altogether over considerable areas, and sometimes changing into common coal."

"I give here eight different sections from the Colinburn Coal:—

"No. 1.—Ballencrieff

	Ft.	In.
Fireclay	1	2½
Gas Coal	0	9
Fireclay	0	9
Fireclay Fakes	6	5

No. 2.—Boghead

	Ft.	In.
Fireclay	6	11
Gas Coal	0	4
Blaes	2	4
Fakes	0	2
Blaes and Coal	1	2
Blaes	3	0
Slatey Black-band	1	1

No. 3.—Boghead

	Ft.	In.
Fireclay	2	10
Cement	0	2
Gas Coal	0	8
Fireclay	0	6
Gray Ironstone	0	6
Coal	1	0
Slatey Black-band	0	6

No. 4.—Torbane

	Ft.	In.
Fireclay	3	10
Cement	0	2
Gas Coal	0	7
Fireclay	0	7
Coal	0	11

No. 5.—Torbanehill

	Ft.	In.
Fakes	7	2
Gas Coal	1	6
Fakes	0	7

No. 6.—Ballencrieff

	Ft.	In.
Sandstone	6	3
Gas Coal	0	1
Fireclay and Coals	0	11
Coal	0	11

No. 7.—Torbanehill

	Ft.	In.
Sandstone	12	5
Daugh	0	2
Gas Coal	0	2
Fireclay	2	8

No. 8.—Barbauchlaw

	Ft.	In.
Sandstone	18	3
Fireclay	0	1
Cement	0	1
Cherry Coal (position)	0	4
Fireclay	0	9
Ironstone	0	6

"Such are a few instances of the changes and irregularities of this deposit, embracing, however, a considerable area . . . it has often been worked as low as 3 inches, and at that rate the colliers' wages, or mere digging, is 18*s.* 6*d.* per ton, diminishing to 10*s.* 6*d.* when it arrives at 8 inches in thickness, and so on down to 2*s.* 6*d.*, according as the thickness increases; but taking into consideration its many wants, irregularities, and changes of thickness (from 28 to 4 inches), and the large number of pits which must be sunk in this wet strata, it is perhaps the most expensive coal to produce in Scotland, costing far more than even our thinnest Black-band Ironstones . . . but it can be done to a profit. The first sales were made at 15*s.* 6*d.* per ton, but it gradually rose to double this . . . the present selling price (1861) being 30*s.* at the pit mouth, and for a short time it reached 44*s.* . . . In the first jury-trial—Gillespie *v.* Russel—it was attempted to be made out that this was not a coal; that action signally failed. And in the recent trial between the coal-oil makers—Binney & Co. *v.* The Clydesdale Chemical Company, the defenders, in their first condescendence, stated that it was not coal; but, finding all the Scotch mining engineers of any eminence, as well as nearly all other practical men, pitted against them, they gave up that part of the plea, and allowed it to be called coal. . . . Palæontologists of considerable eminence have discovered infusoria throughout the whole structure, both in transverse and horizontal section; in short, it only differs from other cannels in giving a larger yield of oil and gas than common, and containing less fixed carbon. It has another peculiarly distinct feature: it is indestructible by atmospheric agency."

"Here is Dr. Penny's elementary analysis in 1853:—

	With Ash	Without Ash
Carbon	63.936	81.159
Hydrogen...	8.858	11.245
Nitrogen	.962	1.221
Sulphur	.320	.406
Oxygen	4.702	5.969
Ash...	21.222	

"The yield is 128 gallons of oil per ton.

"It is a curious fact that, in Fifeshire, about the same distance down from the Red Sandstone we have a seam of gas coal very similar in quality, viz., the Wemyss or Methel Gas Coal, equally precarious and full of wants, with most volatile matter in the top part of it and, like it, sometimes passing into common coal."

In the memoirs of the Geological Survey[1] the following remark is made:—

"The strata immediately underlying the Colinburn Coal appear to be very variable. It is noticeable that this is generally the case with those parts of the Carboniferous formation that contain seams of cannel coal and black-band ironstone. They thicken or thin out rapidly, and the associated seams of coal and ironstone are apt in the same way to change suddenly."

Underlying the Torbanehill gas coal and ironstone there is a seam of impure sulphury coal which has never been worked. It goes under the significant name of the "Stinking Coal".

The coal-seams of the Carboniferous Limestone series, as worked at Bathgate and Wilsontown, will probably be found at a depth of less than 200 fathoms below the ironstone position, as indicated by the bores referred to on p. 190, which show the full section of the strata between the ironstone and Carboniferous Limestone. A description of those coals will be found in another paragraph (p. 183).

There is some evidence that coals may be also found in the Millstone Grit series, underlying the ironstone, corresponding probably with the coals found in a similar position near Slamannan (see p. 161).

I am informed by Mr. Henry Aitken of Falkirk that three coal-seams of a workable thickness were found in the Millstone Grit series at North Couston. There is a tradition in Armadale that a 3-foot coal exists about 20 fathoms below the ironstone position; but although there may be such a coal, it has not yet been worked. As most of the pits in the district are becoming exhausted, attempts will doubtless be made soon to find these under coals.

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[1] Memoir to sheet 31, p. 37.

There is a large amount of water in the strata associated with the seams of the Coal-measures in the Armadale district, and that will be a serious factor in the problem of dealing with the underlying coals of the Carboniferous Limestone series. That, however, is a difficulty which can easily be overcome by engineering skill, although it may be that expensive tubbing will be necessary in sinking through the upper measures.

CHAPTER IX

The Lothian Oil Shales

The Calciferous Sandstone series, as developed in Scotland, consists of two groups of rocks: (*a*) the Upper or Cementstone group; (*b*) the Lower or Red Sandstone group.

The distinguishing feature of the Lower group is, as its name implies, the occurrence of beds of red sandstone and reddish-coloured clays. Sandy limestones, known as Cornstones, are frequently associated with this series, and have been somewhat extensively worked along the outcrops for agricultural purposes. The sandstones or clays are not of any economic value.

The Upper or Cementstone group occurs under two distinct types, each of which has evidently been deposited under different conditions, but probably they were both being laid down at the same time. They are known as the Western or Clyde type and the Eastern or Forth type.

In the recently-issued memoir of the Geology of Fifeshire the Geological Survey have named the subdivisions of the Calciferous Sandstone series somewhat differently from the nomenclature in use in the older memoirs and maps of Scotland. The terms used are as follows:—

"(*b*) Calciferous Sandstone series—Burdiehouse Limestone and oil-shale group, composed of white sandstones and black shales with the Burdiehouse or Burntisland Limestone."

"(*a*) Cementstone group, consisting of red, yellow, and mottled sandstones, red and green sandy clays or marls, and thin seams of cementstone. This group is the eastward extension of the Ballagan beds which underlie the volcanic sheets of the Campsie Hills. At the bottom of the red sandstones lies a remarkably persistent cornstone or sandy limestone, which in central Scotland is taken as the summit of the Upper Old Red Sandstone and base of the Carboniferous system."

Adopting this nomenclature, the Lower or Red Sandstone group would be excluded altogether from the Carboniferous system. The Clyde type of the Calciferous Sandstone would be included in the Cementstone group, and the Forth type would then appear as the Burdiehouse Limestone series.

The importance of thus subdividing the strata is very great in connection with explorations and searching for the oil shales. It is only in the upper or Burdiehouse group that these shales are found, and it is useless to search for them in any beds which are recognized as belonging to the Clyde type.

The "Ballagan beds" of the Cementstones take their name from the spout of Ballagan on the Campsie Hills, about 1 mile north-east of Strathblane. The Cementstones are also found cropping out round the edges of the coal-fields of Ayrshire and the basin of the Clyde, and to the east of Stirling, and in the Devon valley, near Dollar. They are found also on the north side of the Ochil chain, at East Dron, near Bridge of Earn.

The Clyde type is remarkable for the absence of fossil remains of any kind. It appears to have been deposited in small detached basins in which the conditions were not favourable to life, and only a few fragments of plant remains have been found, showing that the adjoining land was covered with vegetation. In the West of Scotland this subdivision is overlain by great sheets of volcanic rocks.

The abundant fossils found in the Burdiehouse Limestone and oil-shale group indicate that it was laid down under quite different conditions. The species of fossils found indicate an alternation of fresh or brackish water conditions with marine conditions. This series is only developed in the basin of the Firth of Forth, extending from the northern edge of Berwickshire to the centre of Linlithgowshire, and including part of Fifeshire. The sandstones are generally of a yellower colour than those of the Cementstones, and they have been extensively quarried for building-stones. Many of the finest buildings in Edinburgh, including the Scott Monument, have been built with those sandstones. This subdivision of the Calciferous Sandstone series is of great economic importance on account of the seams of bituminous shale and of coal which are associated with it. Those shales form the well-known oil shales of Scotland.

The Burdiehouse Limestone, which gives its name to the series, is being extensively worked near Straiton, where it is found 30 feet thick. It has also been worked at Camps, principally for ironmaking purposes. The Camps quarries are now exhausted, but the limestone, which is over 40 feet thick, is being mined from a pit 40 fathoms deep. It is also worked at Burntisland and Aberdour, under the name of the Burntisland Limestone.

An analysis of the Burdiehouse Limestone by Mr. Falconer King of Edinburgh is as follows:—

	Per Cent.
Carbonate of Lime	94.50
Carbonate of Magnesia	2.95
Iron Oxide and Alumina	.92
Carbonaceous Matter	.74
Moisture	.46
Sand and Insoluble Matter	.92
	100.49

From the Hurlet Limestone, at the base of the Carboniferous Limestone series, to the Burdiehouse Limestone, the total thickness of strata is about 2400 feet.

The section of the seams of the West Calder district is as follows:—

	Fms.	Ft.	Ins.
Hurlet Limestone and Coal Strata	75	0	0
Raeburn Shale	0	4	0
Strata	20	0	0

	Fms.	Ft.	Ins.
Mungals Shale	0	2	0
Strata	22	0	0
Two-foot Coal	0	2	0
Houston Marls	30	0	0
Gray Shale	0	2	0
Strata	9	0	0
Houston Coal	1	0	0
Strata	30	0	0
Fells Shale	0	4	0
Strata	40	0	0
Broxburn Shale	0	5	0
Strata	70	0	0
Dunnet Shale	1	2	0
Strata ... 60 fms. to	100	0	0
Barracks Shale and Burdiehouse Limestone	7	0	0
Strata	130	0	0
Position of Pumpherston Shales			

A very instructive section of the West Calder district is given in a paper by Mr. Cadell, published in the *Transactions of the Edinburgh Geological Society*[1]. This section is reproduced, by permission of Mr. Cadell, in Plate X. The characteristic folding and irregularity of the Oil Shales strata are well exhibited in this section. Mr. Cadell points out that it is a curious circumstance that after we leave the shales and go westward into the coal-field above the Mountain Limestone, the complications disappear, and the strata maintain for about 6 miles a perfectly regular northerly strike and westerly dip without any folding, and interrupted only by a few dip faults, some of which are the western continuations of those in the West Calder shale-field.

The West Calder shale district is bounded on the west by the overlying Carboniferous Limestone strata, and on the south and east by faults, and by the successive outcroppings of the Burdiehouse Limestone, stretching from Cobbinshaw, in the south, then along by the line of the Caledonian Railway (Carstairs branch) to Mid-Calder village and Camps, and northward by Pumpherston. On

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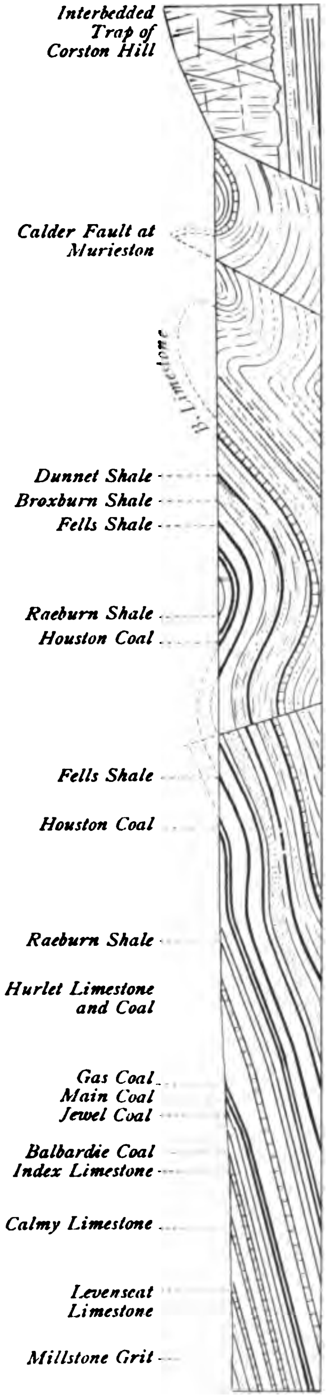
[1] Vol. viii, part 1.



GENERAL SECTION OF THE WEST CALDER SHALE-FIELD AND CARBONIFEROUS LIMESTONE SERIES TO THE WEST (7 MILES)

(Reproduced by permission of Mr. H. M. Cadell)

the north-west it is separated from the Broxburn district by a fault having a downthrow to north of about 250 fathoms.

One of the most remarkable features of the West Calder district is the occurrence of the Pumpherston series of shales. These shales come to the surface at Pumpherston in the form of a saddle back, dipping in all directions from the centre, at an angle of 35 to 45 degrees. The Pumpherston shales have not yet been found in any other part of the district, but it seems quite reasonable to suppose that they will be found at other points when the necessities of mining require explorations to greater depths. Five shale-seams are found at Pumpherston, lying close together, and the following is the general section:—

SECTION OF PUMPHERSTON SHALES

	Fms.	Ft.	Ins.
Burdiehouse Limestone	3	2	0
Strata	130	0	0
Jubilee Shale	1	1	0
Strata	2	2	0
Maybrick Shale	1	0	0
Strata	2	1	0
Curly Shale	1	1	0
Strata	3	4	0
Plain Shale	1	1	6
Strata	1	5	0
Wee Shale	0	4	6

Recent explorations have revealed the existence of another basin, or trough, about 1 mile wide, to the east of Pumpherston, containing at least the Dunnet shale of the Upper series.

The geology of the West Lothian district has been very carefully studied by Mr. Cadell, and his opinion regarding farther extensions of the Pumpherston shales is worthy of careful attention.

"In the grounds of Dalmahoy, north-east of the house, and at Burnwynd, on the south side of the Gogar Burn, a thick shale outcrop is traceable for some distance, which may prove to be the reappearance of the Pumpherston beds to the east of the Camps Limestone, but as yet the position of the shale is uncertain. It may be mentioned that at Broomhill, near Burdiehouse, a thick shale seam crops up close to the great Pentland fault, which seems to represent the Pumpherston section; and on the shore, east of the Forth Bridge, a seam of good curly shale can be seen some distance below the Limestone position. It is interesting economically, if not scientifically, to note these outcrops, as one day, when the Upper Shales become exhausted, mining engineers will have to look about for new seams, and it is well to be able to indicate on which geological horizons new seams may with confidence be sought for."

Mr. Cadell's anticipations have been realized, sooner probably than he expected. The Oakbank Oil Company have now acquired a lease of the shale-field adjoining the River Forth, and a description of the area is given in the following extracts from a recent prospectus issued by that company:—

"Report on the Duddingston Shale-field, on Hopetoun Estate, by Mr. John Gemmell, Mining Engineer.

"Edinburgh, *14th June, 1901.*

'I have gone over this field, seen the sites of the many bore-holes put down, examined the journals thereof, and the tests of samples and cores taken out of them.

'The outcrops of two shale-seams overlying the Queensferry or Burdiehouse Limestone are seen on the shore immediately to the north of the field, where they were recognized and mapped some years ago by Mr. Cadell of Grange.

'These train inland to the Duddingston field, where they lie, as proved by the bores, in a shallow basin, or trough, apparently clean and free of whinstone, the Upper Seam or Dunnet Shale, occupying an area of 175 acres, and the Lower or Barracks Seam, next the limestone, about 420 acres.

'The Dunnet Seam, which is not likely to be deeper than 80 fathoms in any part of the field, has been proved to a depth of 55 fathoms. It is thick and rich, 5 feet of it at this depth yielding 34 gallons of crude oil per ton, and an average thickness of 11 feet 8 inches of it can be worked with a mean yield of 27½ gallons. The 175 acres will produce 4,000,000 tons, which can easily be wrought out at the rate of 500 tons a day, or 150,000 tons a year, and thus last twenty-six to twenty-seven years.

'The Barracks Seam is not proved in the centre of the basin, but 245 acres of the shallower portion of it, beyond the outcrop of the Dunnet Seam, may be reckoned on to contain a thickness of 6 feet of 20-gallon shale, rich in ammonia, or 3,000,000 tons.

'(Signed) JOHN GEMMELL.'

"The shale taken from the various bores has been distilled, and the oil obtained from the Dunnet Seam has been analysed by Mr. A. C. Thomson, the Company's works manager, and the following is his Report:—

"Report on the Shale obtained from the Bores put down to the Dunnet Shale on the Duddingston Shale-field.

"Oakbank, *5th June, 1901.*

'The crude oil and sulphate of ammonia were determined in twenty-five samples of shale obtained from twenty-five different bores cut with the chisel, and from one diamond bore, 3½ inches in diameter, put down in the middle of the shale-field.

'The shale from the various bores, both in thickness and quality, agrees exactly with the diamond-bore average determination.

'I personally divided the diamond-bore core into sections, according to quality and suitability for mining operations on a large scale. There is a continuous vertical face of workable shale, 16 feet 3 inches in thickness. The divisions gave the following results:—

	Oil Per Ton	S./Ammonia Per Ton
If 5 ft. of the seam be worked, the yield is ...	34.3 gals.	34.0 lbs.
,, 10 ft. 4 ins. ,, ,, ,, ...	28.8 ,,	31.5 ,,
,, 13 ft. ,, ,, ,, ...	28.0 ,,	34.4 ,,
,, 16 ft. 3 ins. ,, ,, ,, ...	24.2 ,,	35.0 ,,

'The yield of sulphate of ammonia would be higher in practical working.

'A thickness of workable shale of such quality is quite exceptional. The purification of the crude oil obtained from the section, 10 feet 4 inches thick, gave the undernoted results:—

	Per Cent	Specific Gravity
Naphtha	2.59	.760
Burning Oils	33.91	.807
Intermediate Oils	5.65	.854
Heavy Oils...	15.87	.890
Hard Crude Paraffin ...	11.13	121° M.P. (containing 4% of Oil).
Soft Crude Paraffin ...	4.78	
	73.93	
	1.73	Residue.

'The crude oil is of a very fine quality and easily refined, as shown by the high percentage of products and the exceptionally good yield of the most valuable of all the products—solid paraffin. The percentage of intermediate oils is low, and the viscosity of the heavy oils is particularly good.

'(Signed) A. C. THOMSON.'

The Broxburn shale-field extends northward from the 250-fathom fault to the Firth of Forth, and the shales reappear again at Inverkeithing, on the Fifeshire coast. The section at Broxburn is practically the same as that already given for West Calder, but the Burdiehouse Limestone is somewhat irregular in its occurrence. Many bores in the eastern district of Linlithgowshire, and in the vicinity of Broxburn, have passed through its position without any indication of its presence.

At Burntisland, a shale corresponding with the Barracks Shale, and a shale which probably corresponds with the Dunnet Shale, have been worked to a considerable extent. These works have not been in operation during the recent depression in the oil trade, but there is doubtless a good deal of shale left which may be worked in the future when conditions are more favourable.

The Oakbank Shales occur in a comparatively small basin at Mid-Calder Junction, on the Caledonian Railway. Although almost contiguous with the West Calder district, the section is somewhat different.

SECTION OF SEAMS AT OAKBANK

		Fms.	Ft.	Ins.
	Wee Shale	0	1	0
	Strata	2	1	0
	Big Shale	0	4	0
	Strata	2	0	0
	Lower Big Shale ... 1 fm. to	2	4	0
	Strata	1	4	0
	Curly Shale	1	0	0
	Strata	0	5	0
	Broxburn or M'Lean Shale	0	4	0
	Strata	2	4	0
	Wild Shale or Two-foot Shale	0	4	0
	Strata	48	0	0
	Dunnet Shale	1	0	0
	Strata	7	3	0
	New Shale	1	2	0
	Strata	11	0	0
From Bore	Shale	0	2	0
	Strata	3	4	0
	Shale	1	0	2
	Strata	5	0	0
	Limestone	0	3	0
	Strata	71	3	0
	Burdiehouse Limestone	4	0	0

The value of the Scottish oil shales is generally estimated by the yield per ton of crude oil and ammonia. The value of the crude oil naturally varies considerably with the market fluctuations of the various products. The ammonia is recovered as a by-product in the process of distillation, during which it is converted into a sulphate.

The sulphate of ammonia is largely used for agricultural purposes, and at present is worth about 1*d.* per lb.

Oil shale differs in many of its physical properties from ordinary "blaes", although in outward appearance there is a considerable resemblance. In fact, some of the blaes of the Coal-measures are found at places to contain the ingredients which make the oil shales valuable, and they are worked for that purpose (see p. 161).

The most ready method of distinguishing an oil shale is by the way a thin shaving curls up when cut from a specimen with a sharp knife. Oil shale can also be distinguished by its brown streak, and by the fact that it does not crumble to pieces when weathered as does a common shale or "blaes". The Midlothian oil shale contains from 20 to 25 per cent of volatile matter. The volatile matters are distilled in the retorts, and the remainder forms the "spent shale" which is seen in huge bings at all the oilworks.

The Broxburn shale yields 25 per cent of volatile matters, composed as follows[1]:—

	Per Cent
Crude Oil	12
Ammonia Water	8.5
Gas	4.5

This is the theoretical recovery. The actual recovery in practice is 40 to 45 lbs. of sulphate of ammonia, and 15 to 30 gallons of crude oil per ton.

The Broxburn shale is somewhat variable in value, the yield in some districts being as low as 16 gallons of crude oil and 25 pounds of ammonia per ton.

The Fells shale yields from the top portion as much as 36 gallons of crude oil per ton, and from the lower portion about 18 gallons, while the yield of sulphate of ammonia is from 10 lbs. to 30 lbs. per ton.

The lower the shales are in the section the higher becomes the yield of sulphate of ammonia, and at the same time the yield of crude oil decreases.

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[1] Cadell, *op. cit.*, p. 121.

The products of the Broxburn shale are very numerous, as shown by the following table issued by the Broxburn Company:—

The Oil Shale yields:—
1. Permanent Gas foi Fuel.
2. Crude Oil.
3. Ammonia Water.
4. Spent Shale.

A. Crude Oil distilled gives (*1st distillation*)—
    Green Naphtha, Green Oil, Still Grease.

B. Green Naphtha distilled gives (*2nd distillation*)—
    Naphtha and Light Oil.

C. Green Oil distilled gives (*2nd distillation*)—
    Light Oil, sp. gr. 800; Intermediate Oil, sp. gr. 830; Heavy Oil and Paraffin.

D. Light Oil distilled gives (*3rd distillation*)—
    Naphtha; Petroline; No. 1 Paraffin Oil; Lighthouse Oil; Mineral Sperm Oil and Gas Oil, sp. gr. 840.

E. Heavy Oil and Paraffin cooled and pressed gives—
    Blue Oil and Paraffin Scale.

F. Blue Oil distilled gives (*3rd distillation*)—
    Mineral Colza, sp. gr. 840; Lubricating Oils, sp. gr. 865 to 895.

Between the distillations there are always treatments with oil of vitriol and caustic soda. These treatments remove the impurities in the form of a black tar.

The Pumpherston shales yield 60 to 70 lbs. of sulphate of ammonia, with 20 gallons of crude oil, per ton.

As the result of the keen competition which has been going on with American petroleum refiners since 1877 there has been a great depreciation in the price of most of the products of oil shale. For instance, the price cf burning oil, which was 9½*d* per gallon in 1877, had shrunk to 3½*d* in 1897, although it has since slightly recovered.

This depreciation of values has been met by the Scottish companies by steady and persistent efforts to reduce the cost of treatment, and to make the most of all the by-products.

There is not in commerce a more striking instance of adaptability to circumstance, and of stimulus by misfortune, than is afforded by the Scottish oil industry. The result is that to-day the products recovered from each ton of shale are far beyond what was thought possible thirty years ago. In 1869, from a seam yielding by analysis 30 gallons of crude oil per ton, the actual recovery in practice was:—

12	gallons	Burning Oil.
3.9	„	Lubricating Oil.
2.1	„	Scale.
12	lbs.	Sulphate of Ammonia.

From a shale having a similar analysis the recovery now is:—

12.9	gallons	Burning Oil.
5.4	„	Lubricating Oil.
4.3	„	Scale.
36	lbs.	Sulphate of Ammonia.

The Two-Foot Coal, shown in the section, is of very poor quality, and has never been worked to any serious extent.

The Houston Coal is generally of an inferior quality, with several bands of fireclay. It has been worked somewhat extensively along the outcrop for local purposes. It is now worked to a small extent at some of the oil-shale works at periods when the price of coal is above the normal. The working, however, is expensive on account of the soft roof and pavement.

The Houston Marls underlying the Two-Foot Coal are very interesting from a geological point of view. They consist of green or reddish beds, showing little signs of stratification. The beds vary in thickness up to 6 feet, and are separated from one another by partings of hard kingle or cementstone. When exposed to the weather they crumble down to a powdery mass, and do not split up into layers like shale or blaes. The generally adopted theory of their formation is that they are of volcanic origin. The volcanic ash of which they are composed has been discharged from volcanic craters on the mainland adjoining the lakes in which the shale-beds were being deposited. This ash settled down through the still water in a very fine state of subdivision.

It has been observed in several of the shale-fields that as the shale is followed to the dip it becomes poorer in quality, and it is suggested that some physical condition associated with depth may be the cause of this impoverishment.

CHAPTER X

Mid and East Lothian Coal-Fields

The Coal-fields of Mid and East Lothian, bounded on the one hand by the Pentland Hills and on the other by the Lammermuir Hills, present many geological problems of fascinating interest. Long before the coal-seams were deposited the Lammermuirs must have existed as a range of high ground nearly, if not wholly, surrounded with water. In the creeks and bays of that ancient land we now find the conglomerates of the Old Red Sandstone period, composed of debris washed down from the adjoining Silurian uplands. The Pentland Hills were only brought into existence long ages afterwards, and may be described as quite youthful as compared with the Lammermuirs.

"It was in this part of Scotland that the earliest observations were made on the true character of some of the ancient revolutions of the crust of the earth. The highly tilted Silurian strata and the gently inclined sandstones which rest on their edges, furnishing, as they do, proofs of great terrestial change, caught the eye of Hutton, and in his hands, as well as those of his associates, Playfair and Hall, they were made the means of establishing some of the fundamental principles of geology."

In Mr. Charles Maclaren's *Geology of Fife and the Lothians*, first published in 1834, attention was drawn to the structure of the Pentland Hills, with their continuation in the Braid Hills and Arthur's Seat, in relation to the coal-fields of the Lothians, and in Dr. Milne's memoir on the Lothians coal-fields, published a few years later, the same subject was carefully investigated. The geological pro-

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[1] See Memoirs of Geological Survey Sheet 33, Scot.

blems involved, although the subject of much discussion since then, have not yet been completely solved, and geologists have still many battles to fight on Arthur's Seat and Salisbury Crags. Unfortunately, those engaged in mining, even though they have unexampled opportunities of observing geological phenomena, have seldom the time or the inclination to interest themselves in the subject. But what could be more interesting than the evidences of such stupendous movements of the earth's crust as are exhibited by even a casual examination of the structure of such a range of hills as the Pentlands. For instance, it is evident that the limestones, sandstones, and coal-seams of the Carboniferous period were deposited either under the sea or about the level of the sea. But from the highest bed of the Coal-measures to the bottom of the Calciferous Sandstone the thickness of strata found in Midlothian amounts to about 5000 feet. During all the time these formations were being deposited the bed of the sea must therefore have been sinking slowly and intermittently, and the streams and rivers must have been bringing down debris to fill up the void. It is now generally admitted that the Coal-measures were originally deposited in a continuous stretch across the present site of the Pentland Hills; so that at the end of the Carboniferous period the Old Red Sandstones and Silurian slates which now form the summits of the Pentlands, 1500 feet above the level of the sea, were buried beneath 5000 feet of Carboniferous strata. A force of elevation must then have asserted itself, and as the strata were being slowly pushed upward, they were at the same time being denuded and carried away to form new deposits at the bottom of the German Ocean, and the hills thus assumed their present form. As indicated on the section (Plate XI, fig. 2), the Carboniferous strata have been tilted up on the sides of the hills, and the Old Red Sandstones, &c., have been laid bare on the summits, and every vestige of the overlying Carboniferous rocks washed away.

A similar movement of elevation has taken place at Roman Camp, along a line nearly parallel with the Pentland Hills. In the latter case the force has not been so powerful, or has not been so long continued, but it has been sufficient to bring up the Lower Limestone beds to an elevation of 800 or 900 feet above the sea. As the result of such movements of the earth's crust, a syncline, or trough, about 6 miles wide, has been formed, the axis of which runs parallel with the Pentlands, and in this trough the coal-seams of the Midlothian coal-field are now being worked.

The Upper Coal-measures, which occupy the centre of the trough, correspond with the Middle series of the coal-seams of England. They used to be known as "The Flat Coals", in contradistinction to the "Edge Coals" of the Limestone measures at Niddrie and Gilmerton. It was at first supposed that they had been deposited in horizontal layers over the upturned edges of the Carboniferous Limestone series. It is now known that they are conformable with the Carboniferous Limestone series, and they are lying flat simply because they occupy the centre of the trough. Recent mining operations show that the "Edge Coals" also become horizontal in the centre of the coal-field.

The Upper Coal-measures occupy an area 9 miles long by 2½ miles wide. On the north they are covered by the Firth of Forth, and on the east, west, and south they crop out and are succeeded by the Millstone Grit and Carboniferous Limestone series. The coal-field is divided into two portions by a fault, with an upthrow to the south of about 80 fathoms. This fault, generally known as the Sheriffhall fault, runs east and west, and is situated about 4 miles inland, near the town of Dalkeith. In the northern portion of the field there are several east-and-west faults, mostly local in their occurrence. They become larger going from west to east. The largest, running from Cowpits to Carberry, has a throw of from 16 to 25 fathoms. The faults are more numerous towards the north-east, especially in the vicinity of Musselburgh and Inveresk. Although some of the seams can be traced right across the coal-field there is a marked difference in the character of the deposits on the eastern and western sides of the basin, as shown in the following sections:—

Sections North of Sheriffhall Fault

Western Side of Trough					Eastern Side of Trough			
	Fms.	Ft.	Ins.			Fms.	Ft.	Ins.
Clayknowes Coal	0	4	0					
Strata ... about	20	0	0					
Splint Coal	0	4	6					
Strata	7	0	0					
Rough Coal	0	4	6					
Strata	8	0	0					
Beefie Coal	0	4	6		Beefie Coal	0	4	6
Strata	11	0	0		Strata	13	0	0
Diamond Coal	0	1	0		Diamond Coal	0	3	0
Strata	5	0	0		Strata	6	3	0
Jewel Coal	0	5	0		Jewel Coal	0	4	0
Strata	7	0	0					
Golden Coal	0	2	6					
Strata	24	0	0		Strata	40	0	0
Graymechan Coal	0	2	6		Cowpits Splint (or Little Splint)	0	3	0
Strata	18	0	0		Strata	11	0	0
					Cowpits Five-foot	0	4	9
				Castlesteads Coals	Strata	3	1	0
					Coal	0	3	9
					Strata	1	4	0
					Coal	0	2	2
					Strata	3	2	0
					Coal	0	2	6
					Strata	24	0	0
					Coal	0	3	6
					Strata	5	4	0
Salters Coal	0	4	6		Glass Coal	0	2	0
					Strata	11	0	0
Strata	10	3	0		Barr's Coal	0	3	6
					Strata	4	0	0
Nine-foot Coal	0	5	6		Cowpits Three-foot	0	3	3
Strata	5	1	0		Strata	2	0	0
Fifteen-foot Coal	2	0	6		Cowpits Six-foot	0	5	6
Strata	20	0	0					
Four-foot Coal	0	4	0					
Strata	8	3	0					
Seven-foot Coal	2	0	0					

In the eastern district the Millstone Grit is generally found underlying the Cowpits Six-foot Coal, but on the west the Four-foot and Seven-foot, stretching from the Joppa shore to about Niddrie, occur below the position of the Cowpits seams. A seam below the Seven-foot has also been worked at Melville, and is there known as the Lower Melville. In the centre of the trough the depth to the Clayknowes Coal is only about 60 to 70 fathoms; so that all the seams should be found within a depth of 200 fathoms.

In the southern area the seams which have been thrown up by the Sheriffhall fault have been correspondingly denuded, so that the Upper seams from the Clayknowes to the Cowpits Five-foot have been removed.

Some of those seams should be found in the centre of the trough, but they do not appear to be in a workable condition. At Barleydean, near the southern end of the basin, a seam, 3 feet thick, which might correspond with the Graymechan, has been found, and at other collieries there are some thin seams corresponding with the Castlesteads Coals, but so far as I can ascertain none of these have been worked to any extent.

When the coals in this area were first opened up the correlation with the seams in the northern area was not evident, and they received local names.

The upper seam worked in the southern area was called the Great Seam. This seam appears to be the continuation of the Salters or Glass Coal of the Musselburgh district, and the correlation of the other seams is probably as shown in the following section:—

SECTION OF COALS IN WHITEHILL (ROSLIN) DISTRICT

	Fms.	Ft.	Ins.	
Great Seam ...	0	5	0	Corresponds with Salters
Strata	10	0	0	
Diamond or Rough	0	3	6	„ „ Barr's
Strata	3	3	0	
Splint Coal	0	2	6	„ „ Nine-foot
Strata	5	0	0	

	Fms.	Ft.	Ins.	
Parrot Rough Coal	0	3	0	
Strata	2	0	0	
Jewel Coal	0	2	6	Corresponds with Fifteen-foot
Strata	22	3	0	
Upper Melville ...	0	0	6	,, ,, Four-foot
Strata	6	4	0	
Coal	0	2	10	,, ,, Seven-foot
Strata	6	0	0	
Lower Melville ...	0	3	6	

These seams appear to correspond with the position of the Armadale Coals, but they are of a much better quality.

It is to be noted that the coals are generally thinner on the south side of the Sheriffhall fault. Taking the six seams from the Salters Coal to the Seven-foot Coal, there is a total thickness of coal on the north of the fault amounting to 42 feet. The total thickness of the corresponding six seams south of the fault is only 16 feet 10 inches—a remarkable change in such a short distance. At Sherifthall and Eldin the Great Seam is only about 2 feet thick, but it thickens out towards the south, until at Rosewell and Barleydean it has a thickness of from 6 to 9 feet. It is difficult to see how there can be any connection between this impoverishment of the coal-seams and the occurrence of the Sheriffhall fault, and it may be only a coincidence that the thinning occurs at that point.

Although the Great Seam has been extensively worked, it is of somewhat inferior quality, and is generally sold as a second-class steam coal. It is cheaply worked, however, having a good rock roof, and there is a daugh holing, 4 inches thick, 12 inches to 18 inches from the pavement. The Diamond Coal is an exceedingly good house coal, but it has usually a soft blaes roof, so that it cannot be worked by the longwall system. The Splint Coal is a first-class steam coal with a rock roof. The Parrot Rough has sometimes a band of parrot, or rather shale, containing a very large amount of oil. The section of this seam at Whitehill is as follows:—

	Ft.	Ins.
Coal	2	0
Shale or Parrot	0	8
Stone...	0	5
Coal	1	0
	4	1

The Jewel Coal is a fairly good house and steam coal. It frequently happens that the strata between the Parrot Rough and the Jewel Seams consists of 8 to 10 feet of Sandstone. When this happens the two seams are wrought together on the long-wall system, the roads in the lower seam being used for the working of the upper seam.

The seams below the Jewel are local in their occurrence and have never been worked at Whitehill Colliery.

The dip and rise of the coals ranges from about 1 in 10 at the western outcrop to level in the centre of the trough, and rising again rather more steeply to the eastern outcrop. The depth to the Great Seam in the centre of the trough is only about 70 to 80 fathoms, so that none of the pits in this area are of any great depth.

The principal colliery in this district working the seams of the Coal-measures is the Whitehill Colliery, the property of the Lothian Coal Company—a company which now holds nearly 15,000 acres under lease. This colliery is one of the first in Scotland into which coal-cutting machines were introduced, about twenty-five years ago. Formerly the Rigg and Meiklejohn machines were in use, but this type of machine has been replaced by a machine made at the colliery workshops, and known as the "Whitehill" machine. The Splint and Jewel Coals are best adapted for working with coal-cutting machinery, and they have been most extensively worked by this method. The holing is made in the coal. A circumstance which favours the use of coal-cutting machines here is that the whole area is very free from faults or other troubles, and the inclination is very moderate.

The whole of the coal-seams of the Upper Coal-measures of the Midlothian coal-field are remarkably free from any form of intrusive igneous rock.

The sandstones of the Millstone Grit series are seen cropping out on the shore at Joppa at an angle of 45 to 50 degrees from the horizontal, and they can be traced all round the edges of the Upper Coal-measures. At some places they are at an inclination as low as 10 degrees, but generally they vary from 15 to 25 degrees. This series was called by Maclaren the Roslin Sandstone, as he did not at first correlate it with the Millstone Grit of other parts of Scotland and England, and it is still frequently known by that name. The village of Roslin is built on the Millstone Grits. At Joppa the thickness of the series is about 700 feet at right angles to the stratification, but it thins off towards the south, until at Gilmerton it has a thickness of only 400 feet. At Roslin and Loanhead the thickness is from 600 to 700 feet, but on the eastern side of the basin the thickness does not exceed about 450 feet.

The base of the Millstone Grit series is generally taken as a seam of limestone known as the No. 6 Limestone—a seam which probably corresponds with the Arden or Janet Peat Limestone. This limestone forms the top of the Carboniferous Limestone Series. The Index Limestone, known here as the No. 5 Limestone, lies from 200 to 300 feet below the No. 6 Limestone. As the No. 5 Limestone lies about 20 fathoms above the Splint Coal, which is the first of the lower series, we thus may estimate the distance from the lowest seam of the Coal-measures to the Splint Coal of the Limestone measures as about 700 to 1000 feet.

The Carboniferous Limestone series of Midlothian has a thickness of nearly 400 fathoms, and contains a greater thickness of coal-seams than is found in this series in any other part of Scotland. At Niddrie and Portobello the extent of the outcrop, as shown on the geological map (Plate IX), appears quite insignificant, but this is accounted for by the high dip of the strata. At that point the coal-seams have attained their maximum development, the total aggregate thickness of coal being over 100 feet in twenty-five separate seams. The section (Plate XI) shows the average dip of the strata in this part of the field as about 50 degrees, but at some points the seams are quite vertical, or even overhanging a few degrees.

It will be seen from the section that the seams flatten out towards the dip, and probably cross the trough nearly level. On the eastern side they rise towards the outcrop at an angle of from 15 to 30 degrees. At Loanhead, the Great Seam has been followed downwards on the dip at an angle of from 50 to 60 degrees to a depth of about 1350 feet. At that depth the bottom of the basin has been reached. The seams there take an abrupt turn, and the workings have been continued for some distance eastward, running almost level. It might be expected that at the change of inclination the strata would be very much disturbed and broken, but that is not found to be the case in the Midlothian basin.

At Niddrie the workings on the incline have now reached the greatest depth at which coal is being worked in Scotland, viz. 460 fathoms from the surface. At that depth they begin to flatten, and it appears as if the bottom of the trough had nearly been reached.

In describing the coals of the Carboniferous Limestone series, we will deal with them in four separate districts. First, the district north of the Sheriffhall fault; second, the Loanhead and Newbattle districts; third, the district to the south-west of Penicuik; and fourth, the Haddingtonshire coal-field.

The general impoverishment of the coal-seams towards the south is more noticeable in the Limestone measures than in the Upper Coal-measures. While at the north end of the coal-field there is over 100 feet of coal, at the extreme south there are only one or two thin seams, and even these are of poor quality.

The coal-seams also become thinner on the eastern side of the trough. In the district between Portobello and

Loanhead the Carboniferous Limestone series has a total thickness of about 2400 feet, whereas, on the eastern side of the trough at Wallyford and Carberry, the total thickness is less than half that amount.

The undernoted sections are taken at Niddrie and Musselburgh on the west side of the basin, and at Wallyford, Carberry, and Cousland on the eastern side. The thicknesses given are averages, and the measurements are taken at right angles to the stratification.

SECTIONS OF CARBONIFEROUS LIMESTONE COALS NORTH OF SHERIFFHALL FAULT

Section on Western Side of Basin				Section on Eastern Side of Basin			
	Fms.	Ft.	Ins.		Fms.	Ft.	Ins.
No. 6 Limestone	0	3	0				
Strata, with thin Coal Seams 45 fms. to	50	0	0				
No. 5 Limestone	0	3	0	No. 5 Limestone	0	3	0
Strata 10 fms. to	20	0	0	Strata	10	0	0
Splint Coal	0	2	0	Wood Coal	0	2	0
Strata 50 fms. to	70	0	0	Strata	30	0	0
South Parrot Coal	0	2	0	Splint Coal	0	2	2
Strata	12	0	0	Strata	30	0	0
No. 4 Limestone	0	4	0	No. 4 Limestone	0	3	0
Strata	5	0	0	Strata	5	0	0
Wood Coal	0	2	0	Deception Coal	0	1	9
Strata	4	0	0	Strata	3	0	0
Flex Coal	0	2	6	Cryne Coal	0	2	6
Strata	9	0	0	Strata	3	0	0
Rumble Coal	0	2	8	Mavis Coal	0	1	6
Strata	11	0	0	Strata	5	0	0
Laverock Coal	0	1	6	Coal	0	2	0
Strata	9	0	0	Strata	7	0	0
Great Seam	1	1	0	Great Seam	1	1	0
Strata, with thin Parrot Coals	6	0	0	Strata	1	3	0
Stairhead Coal	0	4	3	Diamond Coal	0	3	0
Strata	9	0	0	Strata	6	0	0
Gillespie or Charlie Coal	0	3	6	Sillerwillie Coal	0	2	9
Strata	4	0	0	Strata	4	0	0
Moffat's Coal	0	2	0	Coal	0	3	0
Strata	4	0	0	Strata	4	0	0
Little Gillespie Coal	0	3	6	Blackbird Coal	0	2	3
Strata	5	0	0	Strata	1	3	0
Stinkie Coal 1 in. to	0	4	0	Coal	0	0	6
Strata	10	0	0	Strata	2	3	0

Section on Western Side of Basin

	Fms.	Ft.	Ins.
Little Splint or Black Chapel Coal	1	0	0
Strata	8	0	0
Perpetual Coal	0	3	0
Strata	2	0	0
Coal	0	2	0
Strata	3	0	0
Corby Craig or Kittle Purse Coal	0	3	0
Strata	12	0	0
Peacock or Stinkie Coal	0	4	0
Strata	6	0	0
Little Splint Coal	0	3	0
Strata	9	0	0
Big Splint or Peacock's Tail Coal	0	4	3
Strata	10	0	0
Real Corby or Corby Craig Coal	1	0	0
Strata	20	0	0
Carlton Coal	0	4	0
Strata	7	0	0
Real Carlton or South Coal	0	3	6
Strata	7	0	0
Blue Coal or North Coal	0	2	6
Strata	20	0	0
No. 3 Limestone.			
Strata, with a Coal Seam	12	0	0
No. 2 Limestone.			
Strata	20	0	0
North Greens Coal	0	5	0
Strata	20	0	0
No. 1 Limestone.			
Strata ... about	250	0	0
Burdiehouse Limestone.			

Section on Eastern Side of Basin

	Fms.	Ft.	Ins.
Coronation Coal or Carberry Jewel	0	3	0
Strata	1	0	0
Coal	0	0	6
Strata	2	0	0
Coal	0	1	0
Strata	5	0	0
Coal (Splint or Parrot Rough) ... 0 to	0	3	0
Strata 5 fms. to	10	0	0
Rough or Smithy Coal	0	1	6
Strata	5	0	0
Splint Coal or Garibaldi	0	5	0
Strata	5	0	0
Lively Coal 8 ins. to	1	0	0
Strata	4	3	0
Little Rough or Kailblades 2 ft. 6 ins. to	0	4	0
Strata	3	0	0
Little Splint or Parrot	0	2	6

A Coal Seam which has been worked at Fuffet and Bryants may correspond with the North Greens Coal.

In the Niddrie district the most important seams are the South Parrot, Great Seam, Stairhead, Corby Craig, Carlton, and North Greens.

In those six seams there is about 25 feet of coal of good workable quality. The other seams are also of workable quality, but it is not profitable to work them as long as the better seams are available.

The South Parrot at Niddrie consists of 18 inches of splint coal and 12 inches of cannel coal. It is, however, local in its occurrence, and is not known on the eastern side of the basin, unless it may be represented by the splint coal shown on the above section.

The Great Seam at Niddrie is principally valuable on account of the parrot coal, which is there found in the upper part of the seam.

The sections of the seam at Niddrie and Gilmerton are as below:—

SECTION OF GREAT SEAM AT NIDDRIE

	Ft.	Ins.
Coal	0	3
Parrot (No. 1 Niddrie) ...	2	3
Ironstone	0	8
Shale	0	3
Coal	1	6
Coal	2	6
Fireclay holing	0	8
Coal (good, but not worked)	3	0

SECTION OF GREAT SEAM AT GILMERTON

	Ft.	Ins.
Coal	0	10
Parrot	0	5
Coal	1	2
Parrot or Shale	0	3
Coal	1	8
Fireclay	0	3
Coal (soft)	3	0

The Parrot Coal thins out both north and south of Niddrie. On the Joppa shore it was found about 12 inches thick, and, as shown above, there was only 5 inches of Parrot at Gilmerton. On the eastern side of the basin there is little or no parrot with the Great Seam north of the Sheriffhall fault, but at Cowden, near Dalkeith, parrot is again found.

The analysis of the Niddrie Cannel Coals by Mr. G. R. Hyslop, F.C.S., is as follows:—

Edmondstone Cannel.—Gas produced from one ton of cannel at 60 deg. Fahr., 30 inches bar., 12,530 cubic feet; illuminating power of gas in standard candles, 31.62.

Great Seam or (*No. 1 Niddrie*) *Cannel.*—Gas produced per ton, 12,330 cubic feet; illuminating power, 32.45 candles.

Stairhead Cannel.—Gas produced per ton, 10,805 cubic feet; illuminating power, 27.57 candles.

In the working of those seams at a high inclination the expense is very heavy, and as the cannel coal is naturally the most profitable, it has been more extensively worked than the common coals. The result is, that many million tons of the common coal have been sacrificed to facilitate the working of the cannel. Of course at the present time there is an abundance of common coals in the section, but that will not always be the case. The Great Seam was formerly worked stoop-and-room, but for the depths recently attained that system was found to be impracticable, and during the last sixteen or twenty years the long-wall system has been generally adopted.

It will certainly be very difficult to recover any large percentage of the coals shown in the foregoing section, where they are lying at the high inclination, but in the bottom of the basin, where they become flat, they may be worked more economically.

The workings in the Great Seam begin to flatten out at a point just below where the edge of the Millstone Grit is shown on the geological map. At that point the depth reached is 2675 feet vertical, and the inclination is about 1 in 5. An exploring "dook" has been continued for about 200 yards farther, and the inclination flattens to about 1 in 10, the depth at the face of this "dook" being 2760 feet. The temperature of the air at the working faces at this depth on 12th July, 1900, was 79°, and the surface temperature on the same day was 71°.

While there is no difficulty in identifying the Great Seam on both sides of the basin, the same cannot be said of the underlying coals. The points at which they have been worked are so far apart that many changes may have occurred in the component parts of the strata, so that the correlation indicated above can only be taken as provisionally correct. It will be many years yet before the workings meet in the centre of the basin, and until then it is obviously impossible to correlate the seams with any degree of certainty.

The next coal-seam worked at Niddrie is the Stairhead Coal, 5 to 6 fathoms below the Great Seam. The section of this seam is as follows:—

	Ft.	Ins.
Steam Coal	1	6
The Stairhead Cannel	2	2
Black-band Ironstone	0	6
Black-band Ironstone (inferior) ...	0	4
Rough Coal (Steam)	1	6

The seams between the Stairhead and the Carlton are mostly of good quality, but have not yet been opened up. The Carlton Coal is a very good house coal, 4 feet to 4 feet 6 inches thick, with a fireclay holing, but somewhat inferior roof. An analysis of this seam by Mr. Stevenson Macadam, Ph.D., Edinburgh, gives the following:—

	Per Cent.
Volatile Combustible Matter	28.68
Fixed Carbon	56.26
Sulphur	.47
Ash	2.44
Moisture	12.15
	100

Coke resulting, 56.26 + 2.44 = 58.7 per cent.

The North Greens Coal, which lies about 70 fathoms below the Carlton, is also a good house coal, and contains about 8 inches of cannel coal.

It lies between the No. 1 and No. 2 Limestones, and has been found in this position all along the western outcrop. Those two limestones appear either to thin out or coalesce before reaching the other side of the basin, and it thus becomes difficult to identify the North Greens Coal on the east side. The Arniston Parrot Coal has been traced for a considerable distance north of Arniston by Cowden and Dalkeith, and has sometimes been taken for the North Greens Coal. There is, however, no limestone overlying it, so that it appears to correspond rather with the position of the Blue or North Coal of Niddrie. It is probable that the same causes which led to the alteration in the limestone seams have prevented the North Greens Coal from being deposited towards the east of the coal-field.

The coal-field on the east side of the basin opposite Niddrie has recently been leased by the Edinburgh Collieries, Limited, and that company propose to sink deep shafts to the Lower measures.

The Carberry Jewel Coal is the best seam in that district. At Carberry pit it is 4 feet 9 inches thick, and of excellent household quality.

A coal known as the Garibaldi has also been worked, occupying a position which may correspond with the Big Splint of Niddrie. It is a good steam coal, 4 feet thick, with a band of dirt occurring in it from 1 to 10 inches thick.

The Great Seam was very extensively worked along the eastern outcrop in previous years, and the old workings allowed to fill up with water. To prevent the ingress of water to the old wastes along the outcrop a system of surface drainage was introduced about ten years ago. Catch drains were cut above the outcrops of the various seams, and these were led into main drains composed of 12-inch fireclay pipes. Altogether about 5 miles of pipes have been laid, and by this means the influx of water has been very materially reduced.

At Prestongrange also the seams are known by local names, as shown by the following section:—

SECTION AT PRESTONGRANGE

	Fms.	Ft.	Ins.
Great Seam	1	0	6
Strata	10	0	0
Diver Coal	0	2	0
Strata	9	3	6
Clay Coal Seam	0	2	6
Strata	4	3	0
Five-foot Seam	0	3	2
Strata	28	3	0
Jewel Coal	0	3	6
Strata	5	3	0
Beggar Coal	0	3	2
Strata	9	0	0
No. 1 Diamond Coal	0	3	0
Strata	16	0	0
No. 2 Diamond Coal	0	3	0
Strata	3	0	0
Limestone	0	2	3

Besides these there are a number of other seams about 2 feet in thickness.

There are several faults between Prestongrange and Wallyford which interrupt the continuity of the seams and make them more difficult to correlate. According to Mr. Milne, the Splint Coal which is found at Wallyford, 42 fathoms below the Great Seam, is represented at Prestongrange by a thin seam only 9 feet below the Great Seam. The Five-foot Coal of Prestongrange would on this supposition correspond with some of the seams underlying the Splint Coal, such as the Carlton Coals or the Four-foot and Three-foot of Elphinstone district. The Jewel Coal of Prestongrange is not the same seam as the Carberry Jewel.

The Diver Seam is probably the same as the Wallyford Splint and the Tranent Jewel.

In the Great Seam at Prestonpans there are old workings made by the monks at a depth of 10 fathoms below sea-level. It is not known how they dealt with the water. In driving the rooms the upper part of the coal has been left in the form of an arch, and the old workings are just like the vaults of a cathedral.

The Prestongrange pit was the first pit in Scotland in which tubbing was applied to keep back the inflow of water. The shaft was sunk in 1829, and was 10 feet in diameter. There was 23 fathoms of cast-iron tubbing placed in it, and it was estimated that by this means feeders of water were dammed back equal to 1150 gallons per minute.

The Forth Collieries, Limited, are reopening the pits at Prestonpans, with the intention of cutting the trap dyke which runs about parallel with the coast at this point, and working the coal underneath the Forth. They have obtained from the Crown a lease of the coal for a distance of 2 miles from the shore.

In the district south of the Sheriffhall fault there are extensive workings on the west side of the trough at Loanhead and Penicuik, and on the east side at Newbattle and Arniston.

It is not easy to establish the correlation between all the seams on the two sides of the trough, but the following sections at Loanhead and Newbattle are arranged to show the relative positions as nearly as possible:—

SECTION OF LOANHEAD COALS				SECTION OF NEWBATTLE COALS			
	Fms.	Ft.	Ins.		Fms.	Ft.	Ins.
South Parrot Coal	0	3	0				
Strata	24	0	0	Strata, with several thin coals			
No. 4 Limestone	2	0	0	No. 4 Limestone	0	4	2
Strata	5	0	0	Strata, with a thin coal	5	0	0
Little Rough Coal	0	2	0	Coal (Deception)	0	2	0
Strata	4	0	0	Strata	3	3	0
Flex Coal	0	5	0	Coal (Cryne)	0	2	6
Strata	9	0	0	Strata, with two coals varying from 5 fms. to	9	0	0
Gas Coal	0	3	0	Coal (Mavis)	0	3	0
No. 3 Ironstone	0	1	3				
Strata	3	3	0	Strata 5 fms. to	9	0	0
Great Seam	1	1	0	Great Seam	1	0	6
Strata	4	0	0	Strata	2	0	0
Stairhead Coal	0	3	4	Diamond Coal	0	2	0
Strata	12	0	0	Strata	5	0	0
Great Gillespie or Charlie Coal	0	3	0	Sillerwillie Coal	0	2	3
Strata	4	0	0	Strata	1	0	0
Moffat's Coal	0	2	0	Coal	0	1	10
Strata	2	0	0	Strata	2	0	0
				Coal	0	2	0
				Strata	4	0	0
				Coal 2 ft. to	0	5	0
				Strata 2 fms. to	5	0	0
Gillespie Coal	0	3	4	Blackbird Coal	0	1	6
Strata	15	0	0	Strata, with thin coal seams	10	0	0
Blackchapel Coal	0	5	0	Coronation Coal	0	3	0
No. 2 Ironstone	0	2	2				
Strata	1	0	0				
Perpetual Coal	0	2	9				
Strata	6	0	0				
Kittlepurse Coal	0	3	0				
Strata	13	0	0	Strata	9	0	0
Peacock Coal	0	5	0	Coal	0	1	11
Strata	12	0	0	Strata	9	0	0

	Fms.	Ft.	Ins.		Fms.	Ft.	Ins.
Rough Coal	0	3	0	Smithy Coal	0	2	3
Strata	3	0	0				
Glass Coal	0	3	6	Strata 6 fms. to	9	0	0
Strata	5	0	0				
No. 1 Ironstone	0	3	0				
Brown's Coal	0	2	6				
Strata	11	0	0				
Stoney Coal or Parrot Rough	0	4	6	Splint Coal	0	4	0
Strata	2	0	0	Strata, with thin coal	7	0	0
Hope's Coal	0	2	0				
Strata	4	0	0				
Beattie's Coal	0	3	0	Coal	0	3	0
Strata	5	0	0				
Corbie Rough Coal	1	0	0				
Strata	20	0	0	Strata, with thin coal	4	0	0
Corbie Splint Coal or Andrew	0	3	0				
Strata	8	0	0				
South Coal	0	5	0	Kailblades Coal 4 ft. to	1	0	0
				Strata	8	0	0
				Little Splint Coal	0	2	0
				Strata	11	0	0
				Coal, Rough	0	2	0
Strata, with two thin coals	4	0	0	Strata	4	0	0
				Coal	0	3	0
				Strata	4	0	0
Blue Coal or North Coal	0	4	6	Arniston Parrot or Jewel	0	3	0
Strata	40	0	0	Strata	3	0	0
No. 3 Limestone	1	3	0	No. 3 Limestone			
Strata, with position of				Strata	uncertain		
No. 2 Limestone	20 to 60	0	0	No. 2 Limestone	uncertain		
North Greens Coal	0	4	6				

At Loanhead and Penicuik valuable seams of black-band ironstone are found. The Upper Ironstone occurs above the Great Seam, and has the following section:—

	Ft.	Ins.
Black-band Ironstone	0	7
Gas Coal	0	12
Black-band Ironstone	0	7
	2	2

The Lower Ironstone occurs between the Peacock and Corbie Splint Coals, at a position corresponding with the

Penston Black-band Ironstone. The following is the section at Loanhead:—

	Ft.	Ins.
Clay Ironstone	0	5
Coal (Inferior Gas)	1	0
Black-band Ironstone	0	10
Parting	0	1
Black-band Ironstone	0	6
	2	10

There is a fireclay holing below the ironstone. Those ironstones have been extensively worked by the Shotts Iron Company, and taken by rail to their ironworks at Shotts. At Penicuik the ironstone workings have been abandoned. While the ironstone was being worked the coal-seams were rather neglected, because the Iron Company were able to obtain a plentiful supply of coal nearer the furnaces and the general markets. There must be a large quantity of coal still to work at Penicuik, and the coal-field has been leased recently with the object of working the coal-seams.

The ironstone workings at Penicuik reached a vertical depth of about 200 fathoms, and at that depth the seams were beginning to flatten out.

At Loanhead the workings are more extensive, and have been continued for some distance towards the centre of the basin. At the outcrop the inclination is 60 degrees.

The drainage of the Loanhead workings has been much facilitated by an adit level, nearly a mile in length, which was driven some time about the eighteenth century. Coming in at the level of the North Esk River, the adit intersects the coal-seams at a depth of about 40 fathoms below the surface. This level must have been a great advantage to the working of the field at a time when pumping machinery was of a very primitive type. It is still very useful in draining off the water from the old outcrop workings, and in reducing the height to which it is necessary to raise the water from the lower levels.

At the present time more than twenty different seams of coal are being worked at Loanhead. On account of the steepness of the workings and the proximity of the seams to one another, it is found necessary to have workings going in different seams at various points in the colliery, so as to maintain a regular output.

The coal-seams which have been principally operated on are, in descending order: the Gas Coal, the Great Seam, Blackchapel, Perpetual, Peacock, Corbie Rough, Corbie Splint, South Coal, North Coal, and North Greens Coal. Inclines have been driven in the Stairhead Seam. At Dryden, several of the seams come so close together as to form one seam several yards in thickness.

The Great Seam does not contain the cannel here as it does at Niddrie, but it is an excellent steam coal. The Peacock, Corbie Splint, and North Coals are good household coals. Most of the seams now in operation are being worked by the long-wall system. From the main levels brake inclines are put up to the full rise of the seam. These inclines are fitted with a carriage for holding the hutches. The carriage is controlled by a brake at the top of the incline, and a counterbalance weight is used for bringing up the carriage and empty hutches. The workings are broken away from either side of the incline, the level roads being driven about 15 yards apart.

At Newbattle and Arniston, the seams which have been principally worked are the Great Seam, the Diamond, the Coronation, the Splint, and the Jewel.

The Diamond Coal at Arniston is from 4 feet to 18 feet below the Great Seam. Although only 2 feet thick it is likely to prove a very profitable working, as recent tests show it to be of a very high quality. It is put on the market under the name of "The Arniston Dundas Coal". The following analysis by Mr. J. Falconer King, F.C.S., analyst to the city of Edinburgh, shows its composition:—

REPORT ON ANALYSIS OF ARNISTON DUNDAS COAL

Report of analysis of sample of coal (representing full section of the Dundas Coal Seam) received from the Arniston Coal Company, Limited, Gorebridge:—

Volatile Matter	36.79
Fixed Carbon	51.11
Ash	1.46
Moisture	10.64
	100.00
Volatile Sulphur	0.25
Fixed Sulphur	0.04
Coke per cent of Coal	52.57
Coke per ton of Coal	10 cwts. 57½ lbs.
Ash per ton of Coal	32.7 lbs.
Specific Gravity	1273.14
Weight of a cubic foot	79.57 lbs.

This coal is, in my opinion, one of excellent quality. It contains very little ash, and the amount of sulphur is small.

It burns easily, with a bright clear flame, giving a good heat, and leaving very little residue. It is a coal which I can highly recommend for household use, as being one that possesses the two very desirable properties for this purpose of being very clean and easily lighted.

The Splint Seam produces an excellent house coal. The Arniston Parrot or Jewel Seam produces three qualities of coal. The Upper Leaf, 1 foot 6 inches thick, is a very superior house coal. The parrot coal in the centre, which averages about 10 inches thick, is a very high quality of cannel coal. The lower part of the seam, also 1 foot 6 inches thick, is a good second-class house coal.

The Cannel Coal, of Newbattle, gives 13,720 cubic feet of gas, with an illuminating power of 35·24 candles, and is of better quality than the Lesmahagow Cannel.

The following is an analysis of the Arniston Parrot Coal made by Mr. Hislop in 1896:—

MINERALOGICAL CHARACTERS

The coal is brownish-black, possesses considerable and strongly brown streak; fracture, rather irregular and undulating, with impressions of stigmaria; cross-fracture, semi-conchoidal to angular, with deposits of ferric bisulphide and calcic carbonate; very cohesive and compact; on the fire it partially intumesces and agglomerates; colour of ash, pale brown; thickness of seam, 8 inches; mean specific gravity, 1192 (water 1000); weight of one cubic foot, 74.50 lbs.

Chemical Analysis

Volatile Matters (containing .69 of sulphur)	52.88 per cent.
Coke, consisting of Carbon 42.48 Sulphur .22 Ash 3.10	45.80 ,,
Water expelled at 212° Fahr.	1.32 ,,
	100.00

Practical Results

Gaseous Products

Gas per ton of coal at 60° Fahr., and 30 in. Bar.	14,135 cubic feet.
Value of gas from one ton of coal in sperm	1810.57 pounds.
Illuminating power of gas in standard candles	37.36 candles.

Liquid Products

Tar per ton of coal	28.85 gallons.
Ammoniacal liquor per ton of coal	5.25 ,,
Strength of ammoniacal liquor	3.60 degrees Twadd.
Hygrometric water per ton of coal	2.95 gallons.
Aqueous absorbent capacity of coal (determined by complete saturation)	1.50 per cent.

Solid Products

Coke per ton of coal	1025.92 pounds.
Carbon in the coke	93.24 per cent.
Ash in the coke	6.76 ,,
Sulphur in coke per ton of coal	4.92 pounds.
Heating power of one pound of coke (water from boiling-point into steam)	12.81 ,,

Remarks.—This is an exceptionally rich cannel coal, yielding as it does a sperm value of illuminating matter equal to 1810½ lbs. per ton, and at same time affords 9.16 cwts. per ton of excellent coke. The coal, moreover, is easily distilled at a good heat, and the foul gas contains about the average total impurities. Compared with Main Lesmahagow Cannel Coal, represented by 100 (calculated on the basis of a production of 13,000 cubic feet of gas and 1535.5 lbs. of sperm per ton, and having regard also to the value of the secondary products and the cost of the purification of the gas), this coal is equal to 124.13.

The Lady Victoria pit, Newbattle, has been sunk to a vertical depth of 276 fathoms, and from the bottom of the pit haulage roads have been driven for over a mile in either direction to open up the coals to the dip. A large fault intersects the field in a north-east and south-west direction, with a downthrow to north-west of over 70 fathoms. Where first met with, in the rise portion of the field, the displacement of this fault is only 40 to 50 fathoms, but it is growing in size towards the centre of the basin.

The principal workings from the Lady Victoria pit are in the Splint and Jewel Seams.

To the south of Arniston the strata flatten out, and the Limestone measures are found occupying a wide stretch of country at Carrington and Temple. The coal-seams appear to thin out in this direction, and become inferior in quality. A large fault running N.E. and S.W. cuts off the higher seams to the south of Gorebridge. The fault has an upthrow to south of about 100 fathoms. Beyond it the parrot coal has been found from 2 inches to 4 inches thick and lying practically level.

At Penicuik the Limestone measures are found occupying a narrow trough about 3 miles wide, and this trough extends to the south-west for a distance of 5 or 6 miles.

Both the coal-seams and the intervening strata thin out in that direction, and what coals have been found are of a comparatively inferior quality. The Corby Craig Coal has been worked at Carlops and at Leadburn, and this is the only seam that is of a good quality. Two or three other seams, known as the Beattie, Stoney, and Rumbles, have also been worked to a small extent along the outcrop.

The coals on the west side of the basin are isolated from any railway, and are only available for supplying the limited local demands. On the east side the Peebles branch of the North British Railway runs along the edge of the coal-field, and no doubt the coals will in the future be worked to a greater extent. The seams at the outcrop on both sides dip at an angle of 30 to 45 degrees, and the centre of the basin is probably covered with the Millstone Grit.

It is noticeable that a large number of the faults in the Midlothian coal-field increase in size towards the dip or the centre of the basin. This fact may be accounted for on the hypothesis that the present form of the basin has to some extent been caused, not only by an upward movement at the edges, but also by a downward movement at the centre. Such a subsidence may readily be connected with the volcanic eruptions of Arthur's Seat and Salisbury Crags. Mr. Milne points out that the trap composing these hills has evidently come from the east. The withdrawal of such a great bulk of material from below the centre of the Esk basin would easily account for the subsidence which has taken place. If this theory is correct, then it may be expected that in the centre of the basin the coal-seams must have been stretched out so as to occupy the wider lateral space. The result to be expected from such a stretching is the fracture of the coal-seams in the centre of the basin, and the fractures thus formed would naturally be filled up with the more plastic fireclays and blaes. In this connection it should be observed that the greatest number of the faults and the greatest depth of the basin is at the northern end—the end nearest to the volcanic eruptions of Arthur's Seat, &c. In the southern end of the basin the faults become fewer, and the central depression of the strata becomes much less.

HADDINGTONSHIRE.—The coals of East Lothian belong exclusively to the Carboniferous Limestone formation. The coal-field is separated from that of Midlothian by an anticlinal axis running about north and south from Roman Camp near Gorebridge to about Prestonpans. To the south of Roman Camp and to the north of Prestonpans the outcrop of some of the coal-seams can be traced swinging round the end of the anticlinal dome, thus forming a connection between the two coal-fields. The section (Plate XI, fig. 2) shows how the coal and limestone seams of the Midlothian basin crop out along the Roman Camp ridge, and then come in again on the other side of the anticlinal axis, forming another basin in Haddingtonshire. Throughout the whole of the latter district the coal-seams above the Great Seam have been removed by denudation, together with all the Upper Limestones. The thinning out of the coal-seams from west to east, which was noticed in the Midlothian basin, is found to continue as they are traced farther east into Haddingtonshire. Thus at Niddrie the seams from the Great Seam to the North Greens contain from 65 to 70 feet of coal; at Wallyford the same series of seams contains only 40 to 45 feet of coal; and the corresponding seams in Haddingtonshire contain only about 30 feet of coal. Many of the Midlothian coal-seams are in Haddingtonshire represented only by thin beds of coal or are absent altogether. This circumstance makes it very difficult to establish any exact correlation between the seams which are worked in Haddingtonshire and those which are worked in Midlothian. The Great Seam has been traced along its outcrop at Prestonpans from the one coal-field to the other. The Arniston Parrot Coal has been traced in the same way from its outcrop at Vogrie across the river Tyne to Pathhead, where it takes the names of the Hauchielin or Parrot Coal. It is somewhat difficult to compile a general section, as the coal-seams and the strata between them vary greatly in different pits, but the following section gives the approximate position and shows the probable connection with the Midlothian seams:—

GENERAL SECTION OF HADDINGTONSHIRE COAL-FIELD

	Fms.	Ft.	Ins.	
Great Seam	1	1	6	Corresponding with Great Seam.
Strata	10	0	0	
Splint Seam	0	5	6	,, ,, Great Gillespie(?)
Strata	2	0	0	
Parrot or Cannel ...	0	2	0	,, ,, Blackchapel(?)
Strata 2 fms. to	5	0	0	
Three-foot Seam ...	0	2	6	,, ,, Perpetual(?)
Strata	3	0	0	
Four-foot Seam ...	0	3	6	,, ,, Kittlepurse(?)
Strata	16	0	0	
Five-foot Seam ...	0	3	6	,, ,, Peacock(?)
Strata	4	3	0	
Penston Triping or Panwood ...	0	1	6	,, ,, Little Splint, Rough, or Smithy(?)
Strata	12	0	0	
Penston B.B. Ironstone	0	1	2	,, ,, Brown's Coal(?)
Strata	2	5	0	

	Fms.	Ft.	Ins.	
Pencaithland Splint ...	0	3	0	Corresponding with Arniston Splint.
Strata	3	3	0	
Rough Coal	0	3	6	" " Kailblades.
Strata	16	0	0	
Hauchielin or Marquis Parrot ...	0	1	6	" " Arniston Parrot.
Strata	6	0	0	
Lower Limestone.				

The Great Seam is generally of fairly good quality as a house and steam coal, but does not contain the bands of parrot which make it so valuable at Niddrie. It is now practically exhausted throughout the field, and has also been wrought for some distance under the sea at Preston Links Colliery. The two best house coals in the section are the Lower portion of the Splint Coal and the Rough or Kailblades Coal.

The Parrot Coal, as its name implies, is principally valuable on account of a band of cannel coal, generally about 8 inches thick, which occurs in the centre of the seam. The strata between the Splint and the Parrot sometimes dwindles down to a few feet only, and in these cases the two seams are extracted together in one working. The Marquis Parrot is only found as a workable seam in the south-west corner of the field, near the village of Pathhead. A section of the seam given by the Geological Survey is:—

	Ft.	Ins.
Hard Coal	0	6
Parrot Coal	0	6
Dross Coal	0	4
	1	4

The various other seams in the section are good for steam purposes, and are second-class house coals.

The seams between the Five-foot Coal and the Splint and Rough Coals are somewhat irregular. A bore at Elphinstone was put down to a depth of 20 fathoms below the Five-foot Seam, but found nothing except a few thin seams. The Geological Survey give the following as the section at Penston:—

SECTION OF STRATA AT PENSTON

	Fms.	Ft.	Ins.
Black-band Ironstone	0	1	2
Gray Fakes	0	0	8
Fakes and Blaes	0	0	10½
Coal	0	0	7½
Gray Fakes	0	5	11
Blaes	0	1	7¼
Ironstone Band	0	0	4
Fakes and Blaes	0	2	0
Sandstone	0	0	9
Fakes and Fireclay	0	1	11
Panwood Coal	0	1	6½
Strata	12	0	0
Splint Coal	0	2	11
Strata	2	4	4
Rough Coal	0	1	3½

The Penston Black-band Ironstone has also been proved at Ormiston and Fountainhall. The ironstone contains as much as 70 per cent of iron. The Panwood Coal shown in above section is marked as "foul coal", but at Penston Colliery a seam known there as the "Triping Coal" is found about 3 fathoms below the ironstone. It is 3 feet 6 inches thick, and is a fairly good steam coal. The Rough Coal or Under Splint is being worked in the same locality.

The seams in this district are lying at an inclination of 1 in 10 to 1 in 15. Even in the centre of the basin they are only from 50 to 100 fathoms from the surface. In most of the seams there is a large area of old workings along the outcrop. At Preston and Tranent coals are supposed to have been worked as early as the thirteenth century—probably by the monks of Newbattle Abbey. At Gladsmuir coal was worked in 1572. Those old workings are a considerable disadvantage in the present working of the field. Being open along the outcrop they readily admit the rainfall to the deeper workings, and thus increase the expense of pumping. They also interfere with the ventilation by causing accumulations of black damp. It is on account of this latter circumstance that some of the collieries use forcing fans instead of the exhausting fans common in other districts. With the forcing fans the black damp is driven out from the old workings instead of being drawn inwards, as was the case when the exhaust fans were used.

With the exception of a whin dyke which runs about east and west through the coal-field at Prestonpans and Seton, and another which is found on the shore at Cockenzie, the field is, like that of Midlothian, remarkably free from igneous rocks. There are also very few faults. The most important are in the southern part of the field, about Ormiston. There are a few faults there running north-east and south-west, but the largest has a displacement not exceeding 35 fathoms.

There is a large extension of the Calciferous Sandstone series to the east of the Haddingtonshire coal-field. To the north and east of the town of Haddington the position of this series is occupied by intrusive and interbedded igneous rocks which occupy the same stratigraphical horizon as the igneous rocks of the Campsie Hills. From Haddington southward to Gifford the igneous rocks are absent, and the Calciferous Sandstone has a development somewhat similar to that of the same series of rocks in the east of Fife. The strata are very much obscured by superficial deposits, so that very little is really known about what coal or shale seams they may or may not contain. At Coalston, near Haddington, some thin coal-seams were formerly wrought, but records of the extent of the workings are not available.

A coal-seam, 18 inches thick, with fireclay below it, is seen cropping out by the side of the Dean, near Fala. In some recent borings for water near Gullane, coal was met with, but I have been unable to ascertain the thickness of the seam.

Anyone travelling over the Lothian coal-field must be struck by the great number of old pits which have been sunk along the outcrops of the coals—most of them circular and lined with stone. In the early years of the nineteenth century these pits were used as ladder pits, and the output of the colliery was raised by women climbing the pits, carrying a load of coals on their backs. The life of a miner and his family at the beginning of the twentieth century is in striking contrast to the life of the same class less than one hundred years ago, as shown by the following extract from Mr. Robert Bald's[1] work (p. 130):—

"In these collieries where this mode is in practice the collier leaves his house for the pit about eleven o'clock at night (attended by his sons, if he has any sufficiently old), when the rest of mankind are retiring to rest. Their first work is to prepare coals, by hewing them down from the walls. In about three hours after, his wife (attended by her daughters, if she has any sufficiently grown) sets out for the pit, having previously wrapped her infant child in a blanket, and left it to the care of an old woman, who, for a small gratuity, keeps three or four children at a time, and who, in their mother's absence, feeds them on *ale or whisky mixed with water*. The children who are a little more advanced are left to the care of a neighbour; and under such treatment it is surprising that they ever grow up or thrive.

"The mother, having thus disposed of her younger children, descends the pit with her older daughters, when each, having a basket of suitable form, lays it down, and into it the large coals are rolled; and such is the weight carried that it frequently takes two men to lift the burden upon their backs: the girls are loaded according to their strength.

"The mother sets out first, carrying a lighted candle in her teeth; the girls follow, and in this manner they proceed to the pit bottom, and with weary steps and slow ascend the stairs, halting occasionally to draw breath, till they arrive at the hill or pit top, where the coals are laid down for sale, and in this manner they go for eight or ten hours almost without resting. It is no uncommon thing to see them, when ascending the pit, weeping most bitterly from the excessive severity of the labour; but the instant they have laid down their burden on the hill, they resume their cheerfulness and return down the pit singing. . . . The weight of coals thus brought to the pit top by a woman in a day amounts to above 36 cwts., and there have been frequent instances of 2 tons being carried. The wages paid them for this work are *eightpence* per day. . . . The height ascended by them when loaded is equal to more than four times that of Arthur's Seat above the level of the sea. . . . There are particular situations and circumstances where bearers may for a few years still be necessary, that is, there may be collieries where, if the system were once abandoned, the colliery would cease to be wrought, or at least would be wrought to great disadvantage; as, for instance, in the edge-seams near Edinburgh, where it will require both genius and a strong and persevering exertion to alter the system; but there is no doubt as to its practicability."

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[1] BALD. *General View of the Coal Trade of Scotland, 1808.*

When the bearer system was finally suppressed, in 1842, by the passing of an act prohibiting the employment of women underground, the edge-coal workings were abandoned, but necessity is the mother of invention, and with modern appliances the workings in these same seams have now reached the greatest depth to which mining has been carried in any part of Scotland, viz., 2760 feet from the surface.

The first Newcomen steam pumping-engine erected in Scotland was at Elphinstone Colliery, in the county of Stirling, about the year 1720, and the second engine of that type was erected at Edmonstone Colliery, near Gilmerton, about 1725.

The Edmonstone engine had a steam cylinder, 28 inches diameter by 9 feet long.

The pit pumps were of elm, bored 9 inches diameter out of a solid tree, and hooped with iron. They were manufactured in London.

The cost of the apparatus appears to have been equal to about £4000, and a royalty of £80 per annum was also payable to the patentees. The engineers who erected the machine were to receive £200 per annum to keep it going and *one half of the clear profits of the colliery after paying all expenses.*[1]

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[1] BALD. *General View of the Coal Trade of Scotland*, 1808.

CHAPTER XI

Clackmannan Coal-Field

Coal-working was carried on in Clackmannanshire at a very early period, the principal inducement being that the coal-seams were found near the shore, and thus convenient for water carriage. There are some accounts extant showing the expense of working the mines in 1623. In the *Statistical Account of Scotland*, published in 1791, some very interesting details of the workings and of life among the mining population are given. At that time there were two collieries at work—the Alloa pit, which was the oldest, 1½ mile from the shore, and the Collyband pit double that distance. The engine pit at Alloa was 48 fathoms deep, and the Collyband pit was 46 fathoms deep. A steam-pump was in use, which had been introduced in 1764. An ingenious contrivance, consisting of a water-wheel, with two sets of buckets for reversing the motion of the wheels, was employed for winding coal.

To work these wheels a large lake was formed at the expense of the proprietor of the Alloa estate. This object was accomplished by constructing a dam across the Gartmorn Valley, giving an area of 140 acres of storage, and thus securing a constant supply of water.

It is not many years since the last of those wheels ceased to be used. It was working pumping machinery at the Old Mill pit, and raised water in two lifts from a depth of 40 fathoms with 11½-inch buckets. The water-wheel was 30 feet in diameter. The Old Mill pit, on which it was working, is said to have been in operation since 1740. It may be remarked that the lake constructed for supplying the water-wheels is now used as a reservoir for the water-supply of the town of Alloa.

One of the earliest railways in Great Britain was constructed at Alloa, and is thus described in the old *Statistical Account of Scotland*.

"In 1785 Alloa wagon-way was worn out and required to be renewed. This was done on a new plan, and is now acknowledged to be the most complete in Britain. A description of it may, therefore, be thought useful. The sleepers are very broad, and only 18 inches from centre to centre. A rail of foreign fir, 4 inches square, is pinned down to them, and another rail of the same dimensions is laid over it, and the whole well beat up in good clay. On the top of the upper rail is laid a bar of malleable iron of 1¾ inch breadth and nearly 6/8 inch thick. The wagons have cast-iron wheels 27½ inches diameter, and are supposed to weigh altogether about 1 ton. The wagon carries 30 cwts. of coals, and three wagons are linked together by chains, so that one horse draws 4½ tons at once."

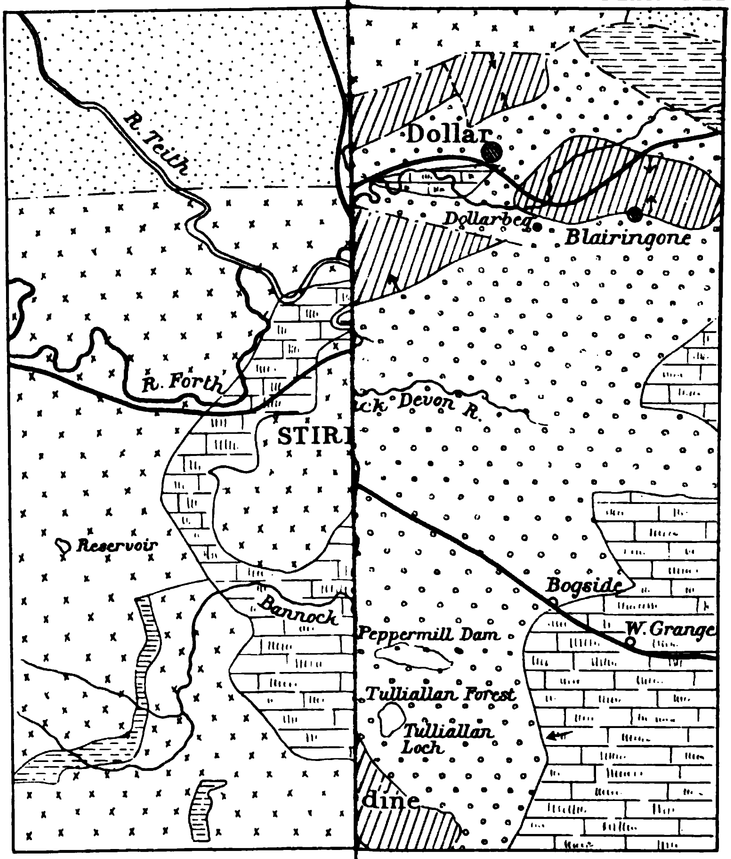
The reverend gentleman who wrote this chapter for the *Statistical Account* seems to have had an eye for more than the mineral resources of his parish, as he closes his record by stating that "many of the young women are pretty".

In 1792 the Devon Ironworks were erected on the banks of the River Devon, and continued in operation until 1858. The furnaces were cut out in the solid rock on the river side. The ironstone used in these furnaces was found above the Nine-foot Coal Seam. It was very thin and irregular, and when it became exhausted the ironworks were shut down, as it was impossible to bring in supplies of iron ore from other districts.

The northern boundary of the Clackmannan coal-field is formed by the great east-and-west boundary fault which runs through by the villages of Menstry, Alva, Tillicoultry, and Dollar. Along the line of this fault the Old Red Sandstones of the Ochil Hills rise abruptly from the

GEOLOGICAL le—2 miles to an inch

PLATE XII



▨ *Coal Measures*

⁘ *Millstone Grit*

▤ *Carboniferous L*

☰ *Calciferous Sand*

⁙ *Old Red Sandsto*

☐ *Whinstone, &c.*

—·⌐— *Faults*

⟶ *Dip of Strata*

plain and attain a height of from 1200 to 1800 feet. The lower beds of the Old Red Sandstone are thus thrown into direct contact with the Upper Sandstones of the Coal-measures, so that the fault here represents a clearly-defined vertical displacement of at least 2 miles! Along the base of these hills a deep groove or valley was cut out by ice or ocean currents to a depth of several hundred feet below the present level of the sea. This ancient valley is now filled up with silt and boulder-clay, but it is met with in the underground coal-workings, and it cuts out all the upper seams.

The Alloa coal-field consists of a basin about 6 miles long and 4 miles broad, having its centre near the site of the old Devon Ironworks. The coal-seams also extend southwards into the detached portion of the county of Perth and Kincardine, this extension being caused by a succession of large faults running east and west, with downthrows to the south varying from 40 to 90 fathoms.

In addition to the Alloa coal-field there are two little detached basins at Dollar and Blairingone, these basins being situated partly in the county of Clackmannan and partly in the county of Fife.

The section of the Clackmannanshire coal-field is as follows:—

		Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
	Strata	14	1	6			
	Rough Coal	0	1	6	14	3	0
	Strata	3	1	11			
	Rough Coal	0	1	8	18	0	7
	Strata	4	4	3			
	Rough Coal	0	2	0	23	0	10
	Strata	7	1	2			
	Coal	0	3	6	30	5	6
	Strata	17	1	3			
Upper Five-Foot	Coal	0	5	2			
	Parting						
	Coal	0	3	1	49	3	0
	Strata	2	2	0			
Four-Foot	Coal	0	2	0			
	Metal	0	0	1			
	Coal	0	2	2	52	3	3
	Strata	3	0	10			

		Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
	Coal	0	2	0	56	0	1
	Strata	0	4	1			
	Coal	0	1	11	57	0	1
	Strata	3	1	3			
Nine-foot	Parrot	0	0	8			
	Rough and Splint	1	3	0	61	5	0
	Strata	5	2	11			
	Coal (M'Neish)	0	2	8	67	4	7
	Strata	2	1	7			
	Coal with Rib of Stone	0	1	4	70	1	6
	Strata	16	0	9			
	Coal	0	1	7	86	3	10
	Strata	5	3	1			
	Coal (Mosie)	0	1	5	92	2	4
	Strata	6	2	4			
	Coal (Cherry or Lower Five-foot)	0	5	3	99	3	11
	Strata	2	0	4			
	Splint Coal	0	2	9	102	1	0
	Strata	11	0	8			
Coalsnaughton Main	Coal	0	2	2			
	Blaes	0	4	1			
	Coal	0	3	8	114	5	7
	Strata	6	4	4			
	Coal	0	1	8	121	5	7

The coal-seams above the Upper Five-foot occur only in a very small area in the centre of the basin. The principal workings are in the Upper Five-foot, the Nine-foot, the Lower Five-foot, and the Splint Coal. In over two-thirds of the area all the workable seams, except the Lower Five-foot and Splint Coals, have been exhausted.

The Nine-foot coal Seam is very irregular in thickness, varying from 2 feet 3 inches to 6 feet 3 inches. The M'Neish Coal and the Coal Mosie are of inferior quality, and have only been worked in patches where they have been found over 3 feet in thickness.

The Cherry or Lower Five-foot Coal is a first-class house coal, averaging 54 inches in thickness. There is a parting in it varying from 3 inches to 12 inches, but it is generally worked as one seam. The top part of the seam is a splint coal, and the bottom part is a free coal. This coal is known commercially as the Alloa Jewel Coal. An analysis by Mr. Stevenson Macadam, Ph.D., &c., made in 1878, gave the following results:—

A. Mean Specific Gravity of the Coal (Water = 1000) ... 1259

B. Proximate Analysis—When heated the Coal yields:—

Volatile Combustible Matter		36.93
Fixed Carbon		55.61
Ash		1.16
Sulphur		0.58
Moisture		5.72
Coke	57.06	100.00

C. Ultimate Analysis—Constituents of the Coal:—

Carbon	78.19
Hydrogen	6.29
Nitrogen	1.49
Oxygen	6.57
Sulphur	0.58
Ash	1.16
Moisture	5.72
	100.00

D. The Calorific or Heat-Producing Power with the foregoing analysis, is as follows:—

1 lb. weight of the Coal during perfect combustion evolves heat sufficient to raise 14.016 lbs. of water one degree (1°) Fahr. in temperature.

General Remarks.—This is an excellent steam coal. The ash is very small, and the true combustible elements—carbon and hydrogen—are very large. In all respects it is a first-class fuel for raising steam. In practical work, and allowing for imperfect combustion and loss of heat in ordinary furnaces, 1 pound of the Alloa Jewel Coal will evaporate fully 9 pounds of water into steam. Whilst it burns readily and gives off inflammable gas, it leaves a large proportion of brightly-glowing cinders or coke which consumes away, leaving a slight amount of ash. It is a very clean and free-burning steam coal.

The Splint Coal underlying the Five-foot Seam is very irregular in thickness, but is of good quality. It is worked wherever found over 24 inches thick, but in many parts of the field it is only 16 inches to 20 inches thick. The quality of the Splint Coal Seam is shown by the following analysis:—

A. Mean Specific Gravity of the Coal (water = 1000) ... 1273

B. Proximate Analysis—When heated the Coal yields:—

Volatile Combustible Matter		35.85
Fixed Carbon		54.79
Ash		4.46
Sulphur		0.34
Moisture		4.56
Coke	59.42	100.00

C. Ultimate Analysis—Constituents of the Coal:—

Carbon	76.48
Hydrogen	6.18
Nitrogen	1.52
Oxygen	6.46
Sulphur	0.34
Ash	4.46
Moisture	4.56
	100.00

D. The Calorific or Heat-producing Power with the foregoing analysis is as follows:—

1 lb. of the Coal during perfect combustion evolves heat sufficient to raise 13.575 lbs. of water one degree (1°) Fahr. in temperature.

General Remarks.—The Alloa Splint Coal is of excellent quality for the raising of steam. The proportion of ash in the coal is small, and there is a high percentage of carbon and hydrogen, which are the true heat-producing constituents of the coal. When used in furnaces, the coal inflames readily, gives off inflammable gases, and then leaves an excellent coke, which continues to burn and evolve a high heat. Making due allowance for loss of heat in ordinary furnaces by the chimney and through imperfect combustion of the coal, the Alloa Splint Coal may be depended upon for the evaporation of 9 pounds of boiling water into steam during the combustion of each pound of coal.

According to the section published by the Geological Survey the Nine-foot Coal of Alloa corresponds with the Virtuewell Coal of Lanarkshire, but the local opinion is that it corresponds rather with the Splint Coal, and that the Lower Five-foot Seam corresponds with the Kiltongue Coal.

The Coalsnaughton Main Coal, and the thin seam underlying it, have only been worked in small patches in the eastern parts of the coal-field.

CHAPTER XII

Fifeshire

The Fifeshire coal-field comprises an area of about 170 square miles, contained in a strip 5 or 6 miles wide and 32 miles long, running about parallel with the River Forth and the Firth of Forth. On the northern boundary the Coal-measures generally come in contact with an irregular line of faulting, throwing up the lower rocks which are found rising farther north into the Ochil Hills. At several points the faulting occurs at some distance north of the coal-field, and the Coal-measures and Carboniferous Limestone strata can then be traced resting on the lower beds of the Calciferous Sandstones, and these in turn are resting on the Old Red Sandstones.

Towards the west, in Clackmannanshire, the fault is found cutting right through the Upper Coal-measures and throwing them into direct contact with the rocks of the Old Red Sandstone series.

On the western boundary the Carboniferous Limestone Coals dip under the Millstone Grit and Coal-measures of the Alloa basin. The southern boundary is the River Forth, but the coal-bearing strata stretch under the water and join with the similar strata of Linlithgowshire and Edinburghshire.

Towards the east the Carboniferous Limestone series crops out and is succeeded by the basement beds of the Carboniferous series, in which some inferior seams of coal are found.

The geological structure is illustrated on the section, fig. 4, Plate XI, in which the Carboniferous Limestones of Bannockburn are shown dipping below the Alloa basin, and rising to the surface again a little to the west of Saline, where the Janet Peat Coal and Limestone crop out. At Loch Glow and Steelend the axis of the great syncline is reached, and the coal-seams east of that district have a general dip towards the east, but occupy several successive basins. The Limestone measures again dip in below the Millstone Grit to the north of Kirkcaldy, and this in turn is succeeded by the Coal-measures of the Dysart and Leven coal-field. Continuing the section across Largo Bay the Limestone measures are again found coming to the surface at Earlsferry, St. Monan, and Pittenweem, where they are succeeded by the basement beds of the Carboniferous series. There can be little doubt that the Coal-measures of Alloa and Leven were at one time spread over the whole of this area, but have since been removed by denudation.

Some of the earliest mining operations in Scotland were carried on in the kingdom of Fife, but the records of these operations are very scanty. What information is available has mostly been preserved in connection with workings by, or for the benefit of, the various orders of monks. In Cochrane Patrick's *Records of Mining in Scotland* two grants are reproduced in full, giving to the abbot and monks of Dunfermline the right to work coal for their own use in the lands of Pittencrief, and it is evident from the language used that coal-mining was even then a familiar operation. The date of this grant was 1291. Coal was being worked at Culross in 1510, and by 1617 the workings had extended some distance beneath the Firth of Forth and were connected with a pit on a small island. King James VI is said to have visited the underground workings of this colliery, and coming to the surface at the island when the tide was full in he imagined that a plot had been made against him. It is interesting to note here that the first pumping plant in Scotland was introduced at the Culross collieries by Sir George Bruce early in the seventeenth century. It consisted of an adaptation of the Egyptian water-wheel or chain-bucket. As the available coals above water-level were becoming very scarce the pumping plant was a great boon to the country.

In 1526 Hector Boece wrote: "In Fiffe ar won black stanis quilk has sa intollerable heit quhair they are kendillit that they resolve and meltis irne, and are thairfore richt proffitable for operation of smithis".

The corporation of Dunfermline has owned and worked the minerals in the vicinity of Dunfermline from a very early period. In a corporation minute, dated 1713, it is stated that the Earl of Rothes sent a letter to the town council of Dunfermline, asking for the loan of two colliers, and the council "warranted the Bailies to lend to the Earl David Murgain and George Brown upon the Earl's hand, to restore them upon demand without expense. And in case Lady Pettercrief want William Watson, warrants the Bailies to lend Watson to her."

From this it will be seen that the miners were not only held to be slaves in the mines in which they were employed, but were subject to the worst conditions of slavery, viz. to be bought and sold, and even lent when occasion required. A minute, dated 27th March, 1754, may also be quoted as throwing a sidelight on another relation between the slaves and their owners. "This day the council ordered William Dickie, late treasurer, to advance to James Wilson, one of the Toun's Coalliers, who is just now about to be married, Twenty Shillings stirline money, being what the toun usually give their workman on that occasion."

The Dunfermline coal-seams, both from the extent and antiquity of the workings and from their central position in the coal-field, are generally taken as typical of the Carboniferous Limestone Coals of Fifeshire. This district is bounded on the north by a fault running through the centre of Loch Fitty towards Carnock and Oakley. On the east, south, and west it is bounded by the outcropping of the coal-seams, thus forming an irregularly-shaped basin about 6 miles long by 2½ miles wide.

The general section of the seams is given on Plate XV. Underneath the Dunfermline Splint Coal there is a seam, known by the expressive name of the Stinking Coal, but it is very impure, with a large percentage of sulphur. For that reason it has not been worked, but doubtless chemists will some day find an economical method of using such a coal and extracting the by-products; so that it may come to be sought after in the future.

The Dunfermline Splint Coal is almost always of very good quality, either as a house coal or as a first-class steam coal. An analysis of this coal from Kingseat Colliery, on the eastern side of the basin, by Mr. G. R. Hislop, gave the following results:—

Mean specific gravity (water being 1000) ...	1225
Weight of 1 cubic foot of coal	76.56 lbs.

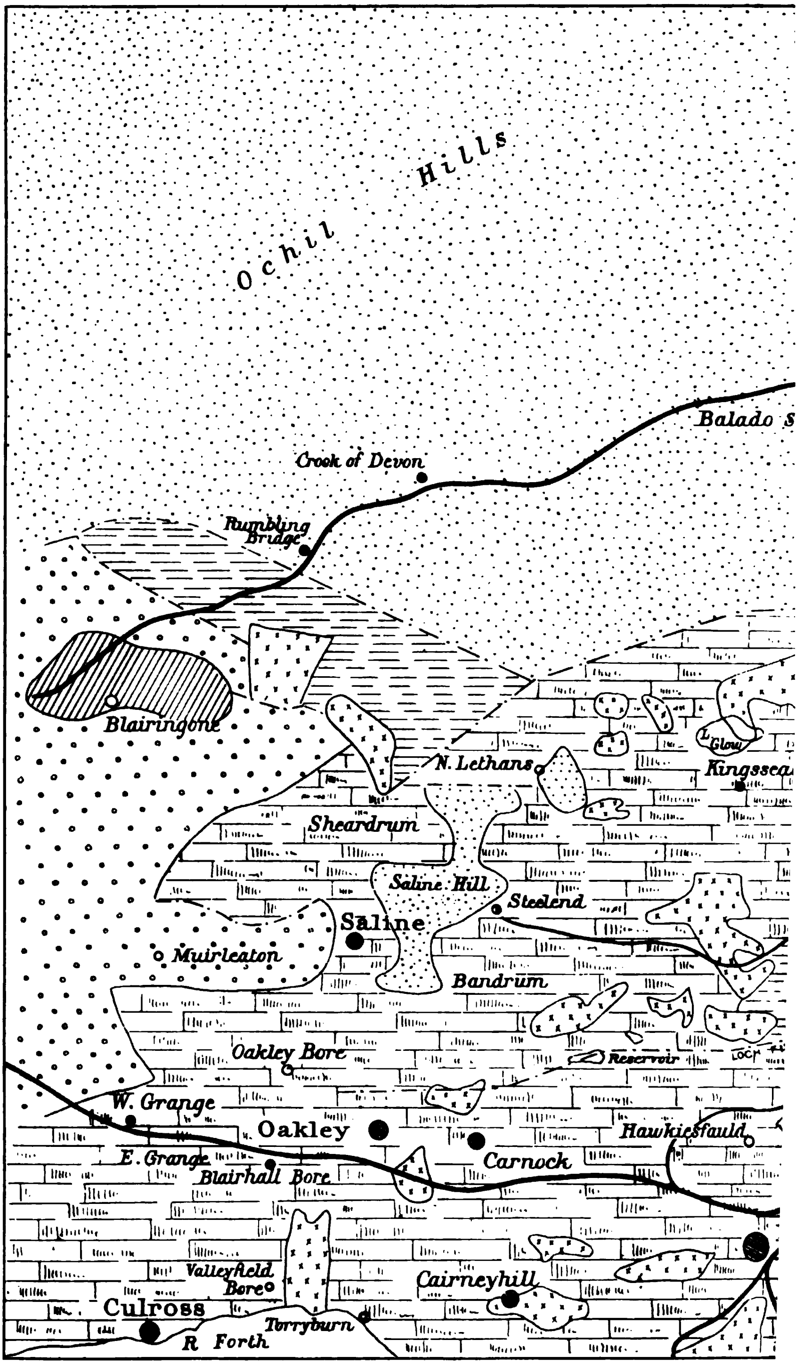
CHEMICAL ANALYSIS

			Per Cent.
Volatile Matters			36.62
Coke	Carbon	52.39	55.52
	Sulphur	.18	
	Ash	2.95	
Water			7.86
			100.00

Gas produced per ton of coal	11,250 cubic feet.
Illuminating power of gas in standard candles	21.62 candles.

On the western side of the basin the Dunfermline Splint appears as a steam coal, with a high percentage of carbon, as shown by this analysis, made by Dr. Anderson of Glasgow, of coal from the Elgin Colliery. Unfortunately the results given are the ultimate analysis, and therefore not so useful for purposes of comparison.

	Per Cent.
Carbon	81.20
Hydrogen	5.16
Sulphur	.84
Nitrogen	1.33
Oxygen	10.61
Ash	.86
	100.00


Ochil Hills
Balado S
Crook of Devon
Rumbling Bridge
Blairingone
N. Lethans
L. Glow
Kingssea
Sheardrum
Saline Hill
Steelend
Saline
Muirleaton
Bandrum
Reservoir
Loch
Oakley Bore
W. Grange
Oakley
Carnock
Hawkiesfauld
E. Grange
Blairhall Bore
Valleyfield Bore
Cairneyhill
Culross
Torryburn
R Forth

At Halbeath and Kingseat the Dunfermline Splint Coal is 4 feet to 4 feet 3 inches thick. At Townhill it is 3 feet 6 inches to 3 feet 9 inches, and at Wellwood it is only 3 feet 5 inches. It is noticeable that this thinning out towards the west is progressive, until at Oakley it is only 1 foot 4 inches to 3 feet in thickness.

This seam has been exhausted throughout the shallower parts of the basin. There is still a considerable quantity to work in the deeper portions, but in the neighbourhood of the Loch Fitty fault it appears at places to be injured by intrusive whins. At the northern part of the workings of Wellwood Colliery it has been converted into a "blind coal" or coarse anthracite by the presence of whinstone. At places the coal is converted into a cinder, and the action of the heat has also affected the roof, making it very soft. There are some areas of this "blind coal" which may yet be worked as an anthracite, as in the case of many similar seams in the West of Scotland.

The Two-foot Coal has been worked to some extent along the outcrops, but is still intact in the deeper workings. In the western side of the basin it consists of 2 feet to 3 feet of coal, sometimes with a fireclay parting in the centre 12 inches thick. At Rosebank it is 2 feet 2 inches to 2 feet 7 inches thick, and has been extensively worked. When the thicker and better seams are exhausted this seam may become of more importance in the other parts of the coal-field.

The Five-foot Coal is generally a bright black coal of an excellent quality for steam purposes, but is only a second-class house coal. This seam also shows a thinning out from east to west. At Halbeath it is over 5 feet thick, at Townhill it averages 4 feet, and at Elgin it is 3 feet 9 inches, including a band of shale 3 inches thick in the lower part of the seam. An analysis of this coal from Lassodie Colliery, made by Dr. John Percy, is as follows:—

	Per Cent.
Carbon	80.99
Hydrogen	5.61
Oxygen and Nitrogen	10.35
Sulphur	.58
Ash	2.47
	100.00
Coke	57.40

Evaporative power calculated from the consumption of 1 lb. of coal, 14·63 lbs. of water.

At Halbeath a seam of Black-band Ironstone, 6 inches to 8 inches thick, is worked along with the Five-foot Coal. Between the Splint Coal and the Five-foot Coal there is a thick post of sandstone which has been extensively quarried along the outcrop.

The Eight-foot Coal lies about 20 to 30 fathoms above the Five-foot Coal. According to the Geological Survey this is the same seam as the Glassee of Lochgelly and the Blawlowan Coal of Fordel, and would thus correspond with the Lochy Coal of Kelty.

The fact that it generally occurs in two leaves, of which the lower sometimes contains cannel coal, has led to the belief that it corresponds to the Lochgelly Splint and Parrot Seams, but a study of the sections on Plate XV shows that the identification given by the Geological Survey is more likely to be correct. The section of the seam at Townhill is as follows:—

	Ft.	Ins.
Coal, Upper Leaf	3	3
Fakes, &c.	4	0
Coal, Under Leaf	3	6

The under leaf is of better quality than the upper, and has been more extensively worked.

At Halbeath and Kingseat there is from 2 to 3 fathoms between the upper and the lower Eight-foot Seams. The upper leaf is 3 feet 4 inches thick, and the lower is from 3 feet 9 inches to 4 feet 4 inches thick.

The lower leaf is the better portion of the seam, and it has frequently been worked out before the upper leaf. It is of a fairly good quality as a steam coal, but can hardly rank as a house coal. That it may also be used for gas-making is shown by an analysis, made by Mr. Hislop, of the coal from Kingseat Colliery.

ANALYSIS OF EIGHT-FOOT COAL

			Per Cent.
Volatile Matters			35.78
Coke ...	Carbon	52.38	55.97
	Sulphur	.23	
	Ash	3.36	
Water expelled			8.25
			100.00

Specific gravity, 1237. Gas produced per ton of coal, 10,650 cubic feet, with an illuminating power of 21.81 candles.

The upper portion of the Eight-foot Coal, although not of a high-class quality, has been extensively worked, and finds a market for manufacturing purposes.

The Mynheer Coal, which occurs between the Eight-foot and Five-foot seams in several of the other districts, is not found as a workable seam in the Dunfermline district. Its position is generally occupied by a thin seam, which sometimes attains a thickness of 15 inches. This seam may also be worked here in the future, when all the other Fifeshire seams are becoming exhausted.

The Swallowdrum Coal of the Dunfermline field appears to correspond with the Lochgelly Splint and Parrot Seams. The Parrot Coal is only found to the east of Dunfermline, where it comes in at Halbeath, Fordel, and Donibristle. At Rosebank, to the west of Dunfermline, it occurs in two plies, known as the Upper and Lower Swallowdrum, each of them being from 4 feet to 4 feet 6 inches thick. At Townhill, Dunfermline, it is from 3 feet to 4 feet thick, and it contains a parting of fireclay varying in thickness from 10 inches to several feet. This fireclay is of very good quality for the manufacture of pipes and sanitary goods, and is put out along with the coal.

The Swallowdrum is generally of very second-class quality, and can only be worked to advantage when there is a considerable demand for coal.

The Cairncubie Coal, known also as the Duddy Davy and the Dean Coal, varies in thickness from 2 feet 8 inches to 3 feet 6 inches. At Townhill it is a first-class house coal, but at Halbeath and Muircockhall it is only of second-class quality. In the other Fifeshire districts this seam is generally of a poor quality.

The Six-foot Coal is only found throughout a small area in the deeper part of the basin. It is 3 feet 9 inches to 4 feet thick, with a bad roof. It is being worked as a steam or manufacturing coal, and is of fair quality for such purposes.

The Bright Coal is a splinty coal with several ribs of blaes, which detract very much from its value. It has only been worked to a very limited extent.

This is the highest seam which is found in the Dunfermline coal-field, and may correspond with the Fourteen-foot or Jersey Coal of the adjoining districts. The overlying coals and ironstones which are worked at Lochgelly to the east, and Steelend and Oakley to the west, have been removed from the Dunfermline field by denudation.

There is a large amount of water associated with the Dunfermline coals, as is to be expected where so many of the seams have been worked along the outcrop.

The water coming from these old workings is, however, in many cases carried away by old adit levels. On the Halbeath estate there is a water level driven in the rock from the bottom of the Mowbray Burn Valley for a distance of 800 yards northwards, and a free drainage is thus provided for all the old workings above that level. The water in the pumping shafts is raised to this level instead of to the surface, thus saving a great deal of expense in pumping. The level was driven prior to 1794, as it is shown on an old plan bearing that date. The water from the collieries north of the town of Dunfermline also passes off in a similar way at a depth of about 47 fathoms, and gets an outlet at Pitfirrane, about 1 mile south of Crossford village.

THE BLAIRADAM AND KELTY COAL-FIELD.—The Carboniferous Limestone series in Fifeshire has been thrown into many folds and plications, and the coal-seams are thus found occupying distinct basins in which the seams are known by local names, and in which they were worked for many years before it became possible to establish the correlation between the various districts.

An example of this is found in the Blairadam field, where the outcrop of the Dunfermline Splint Coal can be traced throughout the greater part of a circle surrounding the intrusive basalt of Blairadam Hill. A similar phenomenon is seen in a little basin about 2½ miles west of the town of Dunfermline. There again the Splint Coal can be traced occupying an isolated basin about 1 mile in diameter. A similar structure can be traced in the Lochgelly coal-field. On the whole, this circumstance is favourable for mining operations, as the outcrops of the seams are again and again brought to the surface, and the coal-bearing strata are spread over a large area without ever reaching an unworkable depth.

The Blairadam and Kelty coal-field occupies a basin lying between the great boundary fault and the Loch Fitty fault, which separates it from the Dunfermline area previously described. A part of the Blairadam field is in Kinross-shire, but it is included here for convenience of description. Until the stratigraphical position had been established by the working of the Lochgelly Ironstone, and by several boreholes proving the position of the Hosie Limestones underlying the coal-seams, there was no means of working out the correlation between the various seams. The position of the Lochgelly Ironstone is shown on the section, Plate XV, and reading from the Dunfermline Splint, which is about 30 fathoms above the Hosie Limestone, there is little difficulty in determining that the Gin

Coal of the Kelty section corresponds with the Five-foot Coal of the Dunfermline section. The Lochy Coal corresponds probably with the Dunfermline Eight-foot Coal, and the Bank Coal with the Cairncubie of Dunfermline, and therefore with the Lochgelly Splint and Parrot seam.

The splint coal is here a little superior to the corresponding seam at Dunfermline. At the Aitken pit it has been found of exceptionally high quality, as shown by the following analysis by Mr. Hislop, dated June 27th, 1896:—

	Per Cent.
Volatile Matters	24.27
Fixed Carbon	73.56
Ash	1.42
Sulphur	.27
Water, at 212° Fahr.	.48
	100.00

Heating power of the coal as determined by Thomson's calorimeter, 1 lb. of the coal by perfect combustion evolves heat sufficient to convert 14.98 lbs. of water from 212° Fahr. into steam. Mr. Hislop remarks that "This is a remarkably pure and valuable house coal; it contains most exceptionally small percentages of ash, water, and sulphur, and possesses great heating power, durability, and great freedom from smoke. It is, in short, an ideal coal for household or steam-raising purposes, and as such it could hardly be excelled." Commercially this is known as the Aitken Wallsend House Coal. The Five-foot Seam, known as the Aitken Hartley Coal, has also been analysed by Mr. Hislop, with the following results:—

			Per Cent.
Volatile Matters (containing .35 of sulphur)			30.12
Coke, consisting of	Carbon	66.50	67.65
	Sulphur	.13	
	Ash	1.02	
Water, expelled at 212° Fahr.			2.23

The quantity of gas produced per ton of coal at 60° Fahr. and 30 inch bar. is 11,320 cubic feet; the illuminating power of the gas in standard candles (per London argand) is 20.87 candles; and the quantity of coke produced per ton of coals is 1515.36 lbs. The coal from these two seams, mixed in equal proportions, is known commercially as the Aitken Navigation Coal.

At the Aitken pit the Dunfermline Splint is found at a depth of 203½ fathoms, and the Five-foot at a depth of 191 fathoms. They rise towards the west with an easy gradient until they crop out about Kelty village, 1¼ mile to the west. The seams probably continue to dip to the east for about 1 mile before commencing to rise towards the Lochgelly and Glencraig coal-fields.

There are two thin seams of coal between the Splint and the Gin or Five-foot Coal. These are not at present workable, but one of them was worked to a small extent near the outcrop, where it contained some ironstone and parrot coal.

Between the Five-foot and the Lochgelly Splint (Bank) Seams the strata and coal-seams are somewhat irregular. At the Lindsay pit the distance between these seams is 40 fathoms, and at the Aitken pit, 1100 yards to the north-east, it has thickened out to 53 fathoms. The Mynheer Seam is found in the Lindsay pit, 2 feet 10 inches thick, 12 fathoms above the Gin Coal, but at Aitken pit it is only a thin seam. On the other hand, the Glassee Coal is found in the Aitken pit, 4 feet 5 inches thick, 32 fathoms above the Gin Coal, but it is not a workable seam at the Lindsay pit. The Lochy Coal, or Dunfermline Eight-foot, is sometimes found as much as 5 feet thick, but is generally of rather inferior quality, and has not been much worked.

The Bank Coal, or Lochgelly Splint, varies in thickness from 4 feet 9 inches to 5 feet 6 inches. It is of fairly good quality as a house and steam coal, and better than the corresponding seam (Swallowdrum) in the Dunfermline district.

Between the Bank Coal and the Jersey Coal there are two seams corresponding with the Cairncubie and Townhill Six-foot Coal.

In the southern part of the field the Cairncubie is found at Lassodie and Lassodie Mill as a first-class house coal 3 feet 3 inches to 4 inches thick, but it appears to thin off going north. It is 3 feet thick at the Lindsay pit, Kelty, but is not considered a workable subject at the Aitken Colliery. At the Lindsay pit it goes under the name of the Duddie Davy Seam.

The second seam, known as the Kinglassie Splint, has been extensively worked in the old Kelty pits, where it is about 3 feet thick. This seam corresponds probably, as above mentioned, with the Six-foot Coal of the Dunfermline section.[1]

The Jersey Coal, probably the Fourteen-foot Coal of Lochgelly, is higher than any of the Dunfermline Coals, unless possibly it is the same as the Bright Coal of Townhill. In the Kelty district it occurs in two leaves separated by a stone band varying from 10 inches to several feet in thickness.

This seam also shows a considerable amount of variation in thickness. Where it is being opened up by the Rosewell Gas Coal Company, near Lassodie Mill, it is a soft house coal 6 feet 6 inches thick. At the Lindsay pit the section is—

	Ft.	Ins.
Upper Leaf	3	0
Stone Band	1	10
Lower Leaf	3	6

At the Aitken pit the upper leaf is 4 feet 2 inches thick, and the lower leaf is 5 feet 8 inches thick, and there the parting between the leaves is several feet thick. In the Lochgelly and eastern districts this seam occurs in three leaves, as shown on page 286. The Main Coal of Kelty may represent the uppermost leaf of the Jersey. At places it is found quite close to the Jersey Coal, although, as a rule, it is separated from that seam by 12 or 14 feet of strata. It consists of 4 feet 6 inches of good coal with 12 inches to 18 inches of inferior head coal. In the Kelty field these seams are generally found as steam or bunker coals.

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[1] *There may be some confusion in the name here. The Kinglassie Splint may be the same seam as the Cairncubie or Duddie Davy, and the Townhill Six-foot may be a thin seam throughout the whole area.*

The position of the Lochgelly Ironstone occurs about 25 feet above the Main Coal. Throughout the western part of the field it has been removed by denudation, but where it has been sunk through in the Aitken and Lindsay pits it is not a workable subject. It has been worked from Lochgelly towards the eastern limit of the Kelty field.

There is another seam of coal, known as the Rough Coal, which has been worked to some extent along the outcrop. It lies about 22 fathoms above the Main Coal. As indicated by its position on the section Plate XV, this seam may correspond with the Four-foot Coal or Six-foot Coal of Saline.

In the Aitken Pit as many as eighteen thin seams of coal were passed through in the 50 fathoms of strata overlying the Main Coal. Some of these seams may be the representatives of the Upper Seams of Saline and Lochgelly.

In the northern part of the field a bore put down on Kinnaird estate, close to the Great North Road, passed through the following seams of coal:—

			Fms.	Ft.	Ins.
		Strata	20	0	0
	1.	Coal	1	1	4
		Strata	17	2	4
	2.	Coal	1	0	4
		Strata	0	0	2
	3.	Coal	1	1	1
		Strata	0	1	6
	4.	Coal	0	4	1
		Strata	12	2	8
	5.	Coal	0	3	8
		Strata	0	0	1
	6.	Coal	0	1	10
		Strata	12	0	0
Marked Foul in Bore.	7.	Coal	0	1	3
		Strata	0	0	11
	8.	Coal	0	1	9
		Strata	24	2	4
	9.	Coal	0	0	4
	10.	Coal	0	3	5

These seams correspond with the Kelty and Blairadam Seams, but the district has not yet been sufficiently explored to enable an exact identification to be made.

The district between the Kelty Collieries and the Loch Fitty fault has recently been opened up by the Rosewell Gas Coal Company, who are working the Jersey Coal and an underlying seam known there as the Rough Coal. This cannot, of course, be the Rough Coal of Kelty, which overlies the Jersey Coal, but corresponds with one of the under seams, probably the Kinglassie Splint or the Lochy Coal. No doubt the lower seams down to the Dunfermline Splint will in course of time be developed there also. A reversed fault found in this field is sketched as shown in fig. 4 in the recently-issued memoir of the Geological Survey, and described as follows:—

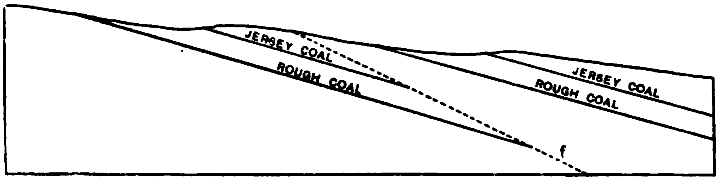

Fig. 4.—Reversed Fault in the Kelty Coal-field

f, Line of reversed fault. It will be seen that in such dislocations a vertical shaft may pass twice through the same seam, and that the workings in the seam on one side of the fault may actually overlie those on the other side.

"A remarkable north-and-south fault diverging from the boundary fault of the Kelty field runs through the Lassodie Mill field. It has a low grade, with a downthrow to the west. It is what is known as a 'reversed fault', consequently the two coals are worked on both sides of it, those on the upthrow side actually overlying those on the downthrow side."

The connection between the Kelty, Blairadam, and Steelend (Saline) coal-fields is illustrated by the sketch section, fig. 5. It will be observed that the Hosie Limestone, which is 240 fathoms deep at the Aitken pit, comes nearly to the surface at Blairadam, and then dips again into a trough below the basalt at Blairadam and Blairenbathie. It is found cropping out again in the Lochornie Burn, as shown in the section. From that point westward to the Lethans the ground is practically unexplored, but some bores put down a little to the south of Lochornie House got a coal about 3 feet thick, which is probably the Dunfermline Splint. At Lethans an ironstone was worked which probably corresponded with the Lochgelly Ironstone, so that the Hosie Limestone must there be nearly 170 fathoms deep. Between these two points there is reason to believe that the strata are folded as shown in the section, but the exact position cannot be known until the district is further explored by bores and pits.

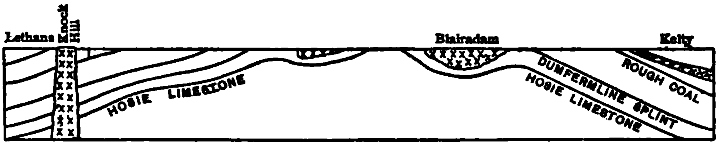

Fig. 5.—Section from Kelty to Lethans (not drawn to scale)

Regarding the coals below the basalt at Blairadam, the following quotation from the Geological Survey memoir is of interest[1]:—"South of Blairadam House . . . some of the coals have been worked in former times by openings along the outcrop. Traces of such shallow pits may be seen in the glen on both sides of the sill. On the west side a seam, supposed to have been the Eight-foot Coal, was mined, where the strata have a dip of 15° to the east. On the east side the dip is north-westerly under the sill at Kiery Craigs, and it is there evident that several seams crop out and have once been mined. Two seams in particular have been worked rather extensively to the north-east of Blairadam House.

"The lower of these is 4 feet thick, and the upper 10 feet. They dip towards the north-west, and the workings were in that direction. In the stream that flows close to the north side of the high-road, a little south from

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[1] Geological Survey Memoir, p. 111.

Kinnaird, one or two bands of volcanic tuff occur containing calcareous layers which may represent the position of the Index Limestone."

Since the above paragraph was written a pit has been sunk about ½ mile west of Blairadam House. The section passed through was as follows:—

SECTION OF COALS AT BLAIRENBATHIE, BLAIRADAM

	Fms.	Ft.	Ins.
Coal	0	1	3
Blaes	0	3	6
Coal	0	2	0
Blaes	1	0	0
Coal	0	0	11
Strata Whinstone Strata	8	0	0
Rough Coal Coal 3 ft. 0 ins. Parting 0 ft. 4 ins. Coal 2 ft. 6 ins.	0	5	10
Strata Whinstone Strata	4	0	0
Lochgelly Ironstone Coal 7 ins. Ironstone 3 ins.	0	0	10
Strata	5	0	0
Main Coal Coal 0 ft. 4 ins. Fakes 0 ft. 6 ins. Coal 6 ft. 6 ins.	1	1	4
Strata	2	0	0
Cairncubie Coal (Upper)	0	3	3
Parting	0	2	0
Cairncubie Coal (Lower)	0	2	8
Strata	1	0	0
Duddie Davie Coal (Foul)	1	0	7
Strata	0	3	9
Swallowdrum Coal	0	2	3
Strata	19	0	0
Whinstone	39	0	0
Lochgelly Splint Coal Burnt Coal 0 ft. 11 ins. Fireclay 0 ft. 2 ins. Burnt Coal 1 ft. 1 in.	0	2	0
Strata	12	0	0
Glassee Coal	0	3	10
Strata	4	0	0
Coal	0	1	10
Strata	10	4	0

		Fms.	Ft.	Ins
Whinstone		2	2	0
Strata		3	2	0
Five-foot Coal		0	4	0
Strata		15	0	0
Splint Coal		0	1	1
Strata		3	2	0
Dunfermline Splint Coal		0	2	6
Strata		3	0	0
Coal		0	1	2
Strata		11	0	0
Stinkie Coal	Coal 2 ft. 10 ins. Blaes 0 ft. 11 ins. Coal 0 ft. 7 ins. Fakes 0 ft. 9 ins. Coal 1 ft. 7 ins.	1	0	8

The whin does not maintain the same horizon throughout the coal-field, but appears to break through the strata from below the Swallowdrum Coal to above the Main Coal, and the three bands of whinstone shown in above section probably come together towards the west.

The Main Coal has been destroyed throughout a considerable area. The underlying seams are also destroyed where the whin breaks through them, but there is every reason to believe that an area of the Lochgelly Splint Coal and of the lower seams remains intact.

The Blairenbathie coal-field has now been acquired by the Fife Coal Company Limited.

The Kelty coal-field, like all the other Fifeshire coal-fields, is very much disturbed by intrusive igneous rocks. Some of these are seen at the surface, but there are many others which are only found in the underground workings. In most cases they run more or less parallel with the stratification, or cut across it at a flat angle. There is a great outburst in the horizon of the lower seams along the outcrop from Roscobie northward to Loch Glow. The volcanic zone seems to rise in the series passing from that line towards the east. At Blairadam it occurs above the Eight-foot Coal. At Kelty it is above the Rough Coal, and in the Aitken sinking a whin over 19 fathoms thick was met with 54 fathoms above the Main Coal.

Farther eastward the volcanic zone is found in the Lochore and Capeldrae field, about 100 fathoms above the Index Limestone. What is probably the eastern termination or outcrop of this volcanic zone is seen in the patches of basalt stretching north-eastward from Hill of Beath to Glencraig. It thus happens that the Lochgelly field is comparatively free from those intrusive rocks. As in other parts of the country, the effect of these intrusions, although on the whole injurious to mining operations, is sometimes beneficial. For instance, the high quality of the Five-foot and Splint Seams at Kelty is to some extent due to the presence of whin sills, which have slightly burned the coal and thus made it very suitable for navigation purposes.

WEST OF FIFE.—The West of Fife district embraces the area to the west of the Blairadam and Dunfermline coal-fields, from the outcrop of the Dunfermline Splint Coal on the west side of the Loch Glow anticlinal axis. On the east it is bounded by the county boundary, where the Carboniferous Limestone dips under the Millstone Grit. Stretching from the River Forth to the great boundary fault it embraces the districts of Culross, Torryburn, Oakley, and Saline Valley.

Mention has already been made of the old Culross workings. Inland, the district was first opened up for the working of seams of Black-band Ironstone, which occupy a position corresponding with the Possil and Lochgelly Ironstones. The bores and pits put down in search of the ironstone have greatly facilitated the more recent operations for the opening up of the coal-seams. The most northerly point at which the ironstone was worked was at Outh Hill, near the Devon Valley road. Bores put down there in 1855 passed through the old ironstone waste, so that the workings must have been prior to that date. The old incline by which the ironstone was brought down to the valley can still be seen.

The ironstone of the district was smelted at the Forth Ironworks, near Oakley.

In 1873 the Carron Iron Company sunk pits on the Blairhall estate, Oakley, and worked the ironstone for seven or eight years. The plant was then sold to the Lochgelly Iron Company, who thought at that time of resuscitating the Lochgelly Ironworks; but as this scheme was not proceeded with, the Coltness Iron Company took over the property in 1883, and have since been working the coal and ironstone.

The general section of the coals at Oakley is here given:—

GENERAL SECTION OF THE OAKLEY DISTRICT

	Fms.	Ft.	Ins.
Castlecary or Levenseat Limestone.			
Strata ... ... 60 fms. to	80	0	0
Janet Peat Limestone	1	1	0
Strata ... ... 2 fms. to	3	0	0
Janet Peat Coal...	1	0	0
Strata	3	0	0
Overton or Oakley Parrot Coal (Capeldrae Parrot)	0	0	10
Strata ... ... 10 fms. to	25	0	0
Crumpy Coal	0	3	2
Strata	14	0	0
Caddel's Parrot Coal (Lochore Parrot)	0	2	0
Strata	37	0	0
Index Limestone	0	1	6
Strata	12	0	0
Inzievar or Blairhall Black-band Ironstone ..	0	1	7
Strata	10	0	0
Blairhall Main Coal	0	3	0
Strata	27	0	0
Upper Black-band Ironstone			
Strata ... ... about	40	0	0
Lower Black-band Ironstone			
Strata	10	0	0
Ontake Coal			
Strata	23	3	0
Three-foot Coal			
Strata	13	0	0
Six-foot Coal (Jersey Coal)			
Strata	14	0	0
Four-foot Coal (Cairncubie)			
Strata containing several seams of coal as in Blairhall and Oakley bores ... ... about	90	0	0
Hosie Limestone	1	2	0

The Blairhall Black-band Ironstone in this section corresponds with a Parrot Coal and Black-band Ironstone found at Lochore (p. 288) 10 fathoms below the Index Limestone, and the Upper and Lower Black-band Ironstones correspond with Lochgelly Ironstone, and are thus in the horizon of the Possil Ironstones.

The strata between Oakley and Saline village have been explored by means of two deep bores put down by the Coltness Iron Company and the Oakley Colliery Company. The Coltness bore (Blairhall diamond bore) was situated about 1 mile west of Oakley Station, on the south side of the railway. The Oakley Colliery Company's bore was situated about half-way between that point and Saline village, near the farm of Sunnyside. The coals found in these bores are shown on Plate XV. The full details of the Blairhall bore are given in the Geological Survey memoir[1] That bore passed through fourteen seams of coal over 2 feet thick, containing an aggregate thickness of 44 feet of coal, and twelve seams between 1 and 2 feet thick, containing an aggregate thickness of 17 feet of coal. The section of the Inzievar or Blairhall Black-band Ironstone, which was met with at a depth of about 80 fathoms, is as follows:—

	Fms.	Ft.	Ins.
Sandstone (roof)	3	2	7
Parrot Coal	0	0	4
Black-band Ironstone	0	1	3
Blaes	0	0	3
Black-band Ironstone	0	0	1
Parroty Blaes	0	0	3

In the Oakley Company's bore the ironstone position was found at 64 fathoms, but it was not a workable subject. Between Oakley and the coast the ironstone has been found in several pits and bores, and it is still being worked at Blairhall Colliery.

About 55 fathoms above the ironstone there is a Parrot Coal known as Caddel's Parrot. It was extensively worked many years ago, and is now supposed to be exhausted, at least in the shallower part of the field. No doubt it extends westward under the Millstone Grit, and may be worked there in the future. It appears to correspond with the Lochore Parrot Coal-Seam.

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[1] Geological Survey Memoir, p. 268.

The Blairhall Main Coal has been worked since 1883. It lies about 22 fathoms below the Index Limestone and 27 fathoms above the Upper Ironstone, and thus occupies a position corresponding with the upper seams of Saline Valley and the Rough Coal of Kelty. It is a good clean coal, 3 feet thick, with a strong blaes roof and a fireclay holing. It is principally used for gas-making purposes.

The Ontake Coal and other coals shown on the section below the Black-band Ironstone have only been worked to a limited extent in shallow pits between Oakley and the coast.

Coals were at one time worked extensively along the coast, at Torry and Torryburn, and also for some distance below high-water mark, towards Preston Island. The coal-seams have not been clearly identified, and are known only by local names. The following section is given in the Geological Survey memoir:—

	Ft.	Ins.
Index Limestone		
Strata	**200 ft. to 300**	**0**
Black-band Ironstone (position of Possil Ironstone)		
Strata	**about 30**	**0**
Lowrie Graham's Coal		
Strata	**130**	**0**
Coal	**3**	**6**
Strata	**50**	**0**
Coal	**2**	**0**
Strata	**30**	**0**
Coal	**0**	**9**
Strata	**90**	**0**
Coal	**9**	**0**
Strata	**80 ft. to 85**	**0**
Coal	**5**	**0**
Strata	**30**	**0**
Coal	**2**	**6**
Strata of unknown thickness, containing the position of the Dumfermline Splint Coal.		
Hosie Limestone.		

"Some coals have also been worked east, between Torry and Torryburn. A seam 6 feet thick, and another 4 feet, crop out in the field to the west of the latter village."

In Sir John Sinclair's *Statistical Account of Scotland* (1791) it is stated that there are many different seams of coal in the parish of Torryburn, of which great fields are still to work, but most of them are under drainage level. "In the north part of Torry is a fine gas coal, 4 feet thick, which is very valuable, and said to sell in the London market at a higher price than any other." It is also stated that the following coals have been found at Torry and Crombie respectively, but no details are given as to depth or quality:—

COALS AT TORRY	COALS AT CROMBIE
11 feet.	7 feet.
9 ,,	5 ,,
6 ,,	4 ,,
5 ,,	4 ,,
4 ,,	3 ,,
3 ,, Parrot	2 ,,
3 ,,	
2 ,,	

In the report of the Royal Commission on Coal Mr. Geddes gives the following list of coals at Blairhall, Crombie, &c.:—

	Ft.	Ins.
Lawrie Graham Coal	4	0
Quartz Coal	2	3
Milton Upper Coal	4	4
Little Coal	1	4
Milton Main Coal	6	6
Little Clinkum Coal	2	3
Kiln Coal	2	0
Coal (supposed the same as Bo'ness Eastermain)	3	6
Blind Coal	2	3

The district between Oakley and Saline and the Lethans has been fairly well proven by means of bores and pits. The Lochgelly Ironstone has been worked out in a considerable area along the county boundary south of Saline village, and also at Steelend, about 1 mile east of Saline, and these workings form a useful index for tracing the coal-seams.

As shown on the map (Plate XIII) there are two east-and-west faults to the north of Oakley, which probably form continuations of the Loch Fitty fault. On account of these faults the Dunfermline Splint Coal, which is 311 fathoms deep in the Blairhall bore, is found at 207 fathoms in the Oakley Company's bore. The two faults thus cause a displacement of from 90 to 100 fathoms, with an upthrow to the north. The general dip of the strata is towards the west or north-west, with an inclination varying from 1 in 20 to 1 in 5. There are many minor faults and irregularities in the inclination, so that it is rather difficult to correlate the seams found in the various bores.

Tracing the Dunfermline Splint Coal from the Oakley Company's bore, it is found first at Kinedder, about ¾ mile to the east. The depth there is 90 fathoms, thus representing an average rise of 1 in 5. At Bandrum, about 1 mile farther to the north-east, it is probably 120 fathoms deep, and the outcrop has been traced with some degree of certainty to the east of Steelend. At the Kinedder pits of the Oakley Steam Coal Colliery, a seam known as the Splint Coal is found, 3 feet 6 inches thick, of fairly good household quality, and a seam known as the Five-foot Coal is found as a steam coal 3 feet thick. These seams may, or may not, be the Dunfermline Splint and Five-foot, but this cannot yet be ascertained with certainty. At Steelend the thickness of the Dunfermline Splint Coal is from 3 to 4 feet. The wavy nature of the strata is well illustrated by a small detached basin of splint coal which occurs at Dunny Gask, a few chain-lengths east of the Steelend outcrop. That basin is only about ¼ mile long by ⅛ mile wide. As the field becomes more fully developed it will probably be found that the coals occur in basin-shaped areas of greater or less extent.

On Bandrum estate the ironstone is found from 40 to 50 fathoms deep, so that the depth to the Dunfermline Splint Coal is probably 120 to 130 fathoms, as above mentioned. Bores on that property show several seams of coal above the ironstone, and at least two of the underlying seams, corresponding with the Jersey and Cairncubie Coals, have also been proven.

Recent borings and sinkings by the West of Fife Coal Company, Ltd., on the Saline Valley (or Steelend) coalfield have proven all the seams of the following section lying throughout a considerable area:—

SECTION AT SALINE VALLEY

	Fms.	Ft.	Ins.
Four-foot Coal (corresponding with Blairhall Main)	0	3	4
Strata	6	3	0
Six-foot Coal (corresponding with Rough Coal of Kelty)	0	5	6
Strata	9	0	0
Coal (has never been worked)	0	3	0
Strata, has not been proved definitely, the Geological Survey give it as	24	0	0
Upper Ironstone.			
Strata	9	0	0
Lower Ironstone.			
Strata	36	0	0
Coal {Upper Leaf, 3 ft. Lower Leaf, 4 ft.} (corresponding with Jersey and Main)	1	1	0
Strata ... about	7	0	0
Coal (corresponding with Cairncubie)	0	1	2
Strata	2	3	0
Coal (corresponding with Lochgelly Splint and Parrot)	0	1	0
Strata	0	5	0
Coal	0	1	10
Strata	30	0	0
Ironstone	0	0	8
Strata	5	0	0
Coal (corresponding with Dunfermline Eight-foot)	0	1	7
Strata	4	2	4
Coal	0	1	3
Strata	3	4	0
Coal 3 ft. 1 in. Parting 0 ft. 0½ in. Coal 0 ft. 6½ ins. (corresponding with Five-foot)	0	3	8
Strata	3	1	8

	Fms.	Ft.	Ins.
Ironstone	0	0	9
Strata, with some thin coals	13	1	2
Coal 1 ft. 4 ins. Fireclay 0 ft. 6 ins. Coal 1 ft. 8 ins. (supposed to be Dunfermline Splint) ...	0	3	6
Strata, proved without any coals	20	0	0

There is some difficulty in naming the most of the seams in this section, and it is hardly possible to correlate them with the general Fifeshire section with any degree of certainty. Until the whole district has been much more fully developed the correlation shown on the foregoing section can only be regarded as conjectural. A comparison of a large number of bores which have been put down in recent years between Steelend, Saline, and Oakley demonstrates that the coal-seams and the intervening strata are very irregular, and there is little doubt that this circumstance has led to the district being very much neglected, and has retarded its development.

As mentioned below, the Saline Hill consists of interbedded volcanic ash. The coals have been worked on both sides of the hill, and probably extend right through below the ash beds.

Above the coals in the foregoing section there is said to be a gas coal, corresponding with Caddel's Parrot, and it was worked among the volcanic ash of Saline Hill.

The Four-foot and Six-foot Coals crop out on the edge of the hill, and have been worked by levels for a distance of ¼ mile beneath the ash-beds.

The Four-foot Coal is of very good quality, without any partings.

The Six-foot Coal has a number of thin ribs of stone running through it, which detract somewhat from its value.

These seams are not affected in any way by the overlying volcanic rock.

The distance from these two seams to the seam which is marked Jersey and Main Coal on the section has not yet been proved by direct boring. The workings in the upper seams are separated from the workings in the lower seam by a fault of which the size is unknown, but the probable distance is 70 to 80 fathoms, as shown in the section. The Jersey and Main Coal has been worked for some years at the Steelend pits, but it has always gone under the name of the Lochgelly Splint and Parrot.

The section of the working has certainly a resemblance to the Lochgelly Splint and Parrot as shown below.

SECTION OF JERSEY AND MAIN COAL SEAMS AT STEELEND

	Ft.	Ins.
Sandstone Roof.		
Top Coal	2	10
Wild Coal	1	0
Sandstone	3	6
Coal with Bands of Dirt	0	6
Coal	1	0
Fireclay	1	6
Bottom Coal	2	4
Fireclay Pavement.		

The top coal is a very good quality of steam coal, and is also used for smithy purposes. It has a good roof, and is easily worked.

In the lower seam there is a parrot coal about 4 inches thick, but it adheres to the free coal and can hardly be kept separate from it. The whole seam, including the parrot, is very suitable for gas-making purposes.

None of the underlying seams have yet been opened up to any great extent, but a large area of the Five-foot and Dunfermline Splint Coals has been proved by boring, and pits are now being sunk to develop those seams.

An important bore has just been completed (March, 1901) for the Valleyfield Coal Company, Ltd., at a point about ½ mile west of the village of Torry. This bore is of great importance as showing the continuation of the coal-seams southward from the Coltness Company's Blairhall bore, and the journal is here reproduced in full by the courtesy of the Valleyfield Company.

The position of the Oakley, Blairhall, and Valleyfield bores is shown on Plate XIII.

JOURNAL OF BORE ON THE SHORE OF THE FORTH AT VALLEYFIELD

	Thickness of Strata.			Depth from Surface.		
	Fm.	Ft.	In.	Fm.	Ft.	In.
Surface with boulders	9	3	6			
Strata	3	3	3			
Coal...	0	2	3	13	3	0
Fakes and Sandstone	0	5	6			
Fakes	0	4	6			
Fireclay	0	5	0			
Blaes	1	0	4			
Fakes	1	4	0			
Sandstone... ...	4	3	6			
Blaes	0	0	10			
Coal...	0	0	9	23	3	5
Fireclay	0	1	1			
Coaly Blaes ...	0	1	2	23	5	8
Fakes	0	4	10			
Blaes and Balls ..	0	2	0			
Fakes	1	1	3			
Sandstone... ...	0	1	2			
Fakes	0	2	0			
Sandstone... ...	1	1	10			
Blaes	0	0	3			
Whinstone ...	0	4	6	28	5	6
Fakes	1	0	0			
Blaes	0	3	0			
Fakes	0	2	9			
Sandstone... ...	2	3	11			
Whinstone ...	0	3	3	34	0	4
Blaes	0	2	7			
Hard Sandstone ...	0	4	8			
Fakes	0	2	0			
Whinstone ...	0	1	8	35	5	3
Fakes	0	0	2			
Coal, burnt ...	0	1	5			
Sandstone... ...	0	3	6			
Blaes	0	3	4			
Fakes	0	3	5			
Limestone Fakes...	0	0	7			
Fakes	0	2	5			
Sandstone... ...	0	4	6			
Blaes	0	3	0			
Sandstone... ...	0	5	0			
Fakes	1	3	6			
Fakes and Sandstone	2	2	0			
Hard Sandstone ...	1	5	4			
Fakes	0	3	0			
Sandstone... ...	0	1	10			
Fakes and Sandstone	0	4	3			
Fakes	1	1	3			
Sandstone... ...	0	0	6			
Fakes	0	0	3			
Parrot and Ironstone B.B.	0	0	7	49	1	1
Blaes	0	0	10			
Fakes	0	0	9			
Blaes	0	2	8			
Coal...	0	1	4	50	0	8
Fakes	0	0	6			
Fakey Sandstone...	0	1	7			
Fakes	0	0	3			
Hard Sandstone ...	0	2	4			
Extra Hard Sandstone	0	2	3			
Fakes and Sandstone	0	3	9			
Fakes	0	5	4			
Blaes	0	2	9			
Coal, Parrot ...	0	0	3½			
Coal, Rough ...	0	0	8½	53	2	5
Fakes and Blaes ...	0	5	9			
Sandstone... ...	9	3	5			
Blaes	0	3	4			
Coal...	0	0	9	64	3	8
Blaes	0	1	6			
Fakes	0	4	4			
Blaes	0	2	6			
Fakes	0	1	2			
Blaes	0	2	0			
Fakes and Sandstone	0	3	0			
Sandstone... ...	1	1	0			
Fakes	0	1	6			
Blaes and Balls ...	1	0	4			
Fakes	0	2	6			
Fakes and Balls ...	1	0	3			
Blaes	0	2	0			
Sandstone... ...	0	1	9			
Limey Stone ...	0	0	8			
Fakes and Balls ...	0	5	3			
Fakes and Fireclay	1	3	0			
Fakes and Blaes ...	0	3	0			
Fakes	0	2	3			
Sandstone... ...	0	1	0			
Fakes	0	1	6			
Blaes	0	2	9			
Sandstone... ...	1	0	6			
Blaes	0	1	9			
Fakes	0	0	6			
Coal...	0	0	11			

		Thickness of Strata.			Depth from Surface.		
		Fm.	Ft.	In.	Fm.	Ft.	In.
Sandstone		0	0	5			
Fakes and Balls		0	4	0			
Sandstone, hard		1	1	6			
Fakes and Sandstone, hard		0	1	3			
Sandstone, hard		0	1	0			
Fakes		0	2	6			
Blaes		0	0	7½			
Yellow Stone		0	0	0½			
Coal		0	1	7	80	3	6
Fakey Fireclay		0	0	8			
Coal		0	1	6	80	5	8
Sandstone		0	0	2			
Coal		0	0	5	81	0	3
Fireclay		0	0	2			
Fakey Sandstone		0	1	0			
Sandstone, hard		1	4	9			
Fakes		0	1	6			
Blaes		0	3	1			
Irony Blaes B.B.		0	1	0	83	5	9
Fakes		0	3	6			
Sandstone, hard		0	3	4			
Fakes and Sandstone		1	0	8			
Fakes		0	3	3			
Coaly Blaes		0	0	10			
Coal		0	0	6	86	5	10
Coaly Blaes		0	1	4			
Fakes		0	0	5			
Fakes and Sandstone		1	5	5			
Fakes		0	1	3			
Blaes		0	1	0			
Ironstone		0	0	2			
Coal		0	0	3			
Blaes		0	0	2			
Fakes		1	0	2			
Blaes		0	5	10			
Fakes		0	4	7			
Sandstone		0	2	4			
Fakes		1	0	6			
Blaes		0	4	0			
Fakes		0	0	6			
Blaes		0	4	5			
Coal		0	1	7	95	3	9
Blaes		0	0	6			
Fakes		0	0	4			
Sandstone		1	3	2			
Fakes		0	3	0			
Blaes		0	2	3			
Coaly Blaes		0	2	2	98	3	2
Ironstone, B.B. (Kelty)		0	0	5	98	3	7
Blaes		0	0	3			
Fakes		0	4	0			
Blaes		1	2	6			
Fakes		1	0	0			
Sandstone		6	5	4			
Blaes		0	1	2			
Coal		0	0	11	108	5	9
Fakes		0	3	3			
Fakes and Sandstone		0	2	0			
Blaes		0	2	6			
Fakes		0	1	8			
Hard Fakes and Sandstone		0	4	6			
Blaes		0	0	10			
Fakes and Sandstone		0	0	6			
Blaes		0	2	6			
Sandstone		0	1	9			
Fakes		0	1	3			
Sandstone		0	0	4			
Blaes		0	3	8			
Fakes		0	5	6			
Sandstone, hard		2	0	0			
Fakes		0	1	4			
Sandstone		0	0	2			
Fakes		0	0	2			
Sandstone		0	1	3			
Fakes		0	0	4			
Fakey Sandstone		1	2	1			
Fakes		0	4	2			
Blaes		0	5	1	119	2	7
Coal	Cairncubie or Fourteen-foot Seam	0	0	8			
Blaes		0	0	4			
Coal		0	0	5			
Brown Stone		0	0	2			
Coal		0	1	11			
Coaly Sclit		0	0	1½			
Coal		0	4	3	120	4	5
Fakes		2	0	9			
Fakey Sandstone		0	3	0			
Sandstone		2	1	4			
Fakey Sandstone		0	2	0			
Sandstone		1	5	0			
Fakes		1	1	0			
Fakes and Sandstone		1	2	6			
Sandstone		1	4	8			
Fakes		0	1	3			
Sandstone, coarse		1	1	3			
Blaes		0	1	6			
Fakey Sandstone		0	2	3			
Blaes		0	3	2			
Sandstone		0	1	1			

	Thickness of Strata.			Depth from Surface.		
	Fm.	Ft.	In.	Fm.	Ft.	In.
Blaes	0	0	3			
Coal	0	1	9	135	1	2
Blaes	0	1	11			
Coal, blind	0	1	3½	135	4	5
Fakes and Blaes	0	4	9			
Whinstone	22	1	10	158	5	0
Fakes	0	3	0			
Fakes and Blaes	0	5	0			
Fakes and Sandstone	0	2	2			
Sandstone	0	3	0			
Fakes and Sandstone	0	5	0			
Fakes and Blaes	0	4	10			
Coaly Blaes, soft	0	1	3	162	5	3
Fireclay	0	2	0			
Fakes and Sandstone	1	4	0			
Blaes	1	0	6			
Blaes and Mussel-shells	0	5	0	166	4	9
Fakes and Sandstone	1	4	6			
Fakes, dark	0	2	6			
Blaes	0	1	0			
Fakes and Sandstone	0	4	6			
Fakey Sandstone	0	3	0			
Sandstone	1	1	0			
Sandstone, hard	0	3	0			
Fakey Sandstone	0	2	0			
Fakes	0	3	6			
Fakes and Blaes	0	4	8			
Blaes	1	2	6			
Irony Fakes	0	0	7			
Blaes	0	2	11			
Fakes and Blaes	2	1	10			
Sandstone	4	3	5			
Sandstone, hard	6	3	11			
Coal	0	0	9	189	2	4
Sandstone	0	4	6			
Coal (Lochgelly Splint)	0	1	6	190	2	4
Fakes	0	1	0			
Sandstone	0	5	0			
Fakes and Sandstone	1	4	6			
Blaes	1	2	5			
Parroty Blaes	0	1	0			
Blaes	0	0	10			
Fakes	0	1	9			
Blaes	1	3	0			
Fakes and Blaes	0	3	0			
Blaes	0	2	0			
Coal	0	0	6			
Blaes	2	3	2			
Fakes and Sandstone	0	4	4			
Sandstone	0	2	4			

	Thickness of Strata.			Depth from Surface.		
	Fm.	Ft.	In.	Fm.	Ft.	In.
Fakes	0	1	4			
Sandstone	1	0	0			
Fakes	0	1	9			
Coaly Blaes	0	1	11	203	0	2
Fakes and Sandstone	1	2	6			
Fakes	0	1	2			
Blaes	1	3	6			
Fakes	0	0	2			
Blaes	0	0	4			
Coaly Blaes (Glassee)	0	0	8	206	2	6
Blaes	0	2	0			
Fakes	1	2	1			
Fakes and Sandstone	0	3	3			
Sandstone	6	5	4			
Fakes and Blaes	1	1	2			
Blaes	0	5	6			
Fakey Rib	0	0	2			
Blaes	0	3	6			
Ironstone	0	0	3	218	1	9
Blaes	0	1	0			
Ironstone	0	0	2	218	2	11
Fakes and Blaes	1	0	1			
Hard Rib	0	0	3			
Fakes and Blaes	0	2	6			
Coal	0	0	10	220	0	7
Fakes, Fireclay, and Balls	0	1	5			
Coal (Mynheer)	0	2	3	220	4	3
Fakes and Fireclay	0	0	9			
Blaes	0	0	6			
Fakes	1	0	0			
Coaly Blaes	0	1	6	222	1	0
Fakes and Sandstone	1	5	0			
Fakes	1	0	0			
Blaes	0	4	11			
Ironstone, B.B.	0	0	2½	225	5	1½
Coal	0	0	6½	225	5	8
Fakes	0	2	0			
Sandstone	1	0	6			
Fakes and Sandstone	2	4	3			
Fakes	0	1	6			
Blaes	1	1	4	231	3	3
Coal	0	5	7			
Stone	0	0	2			
Coal	0	1	5			
Stone	0	0	2			
Coal	0	1	4	232	5	11
Fakey Sandstone	1	0	0			
Blaes	1	3	5			
Ironstone, C.B.	0	0	2½	235	3	6½
Blaes	0	3	8			

	Thickness of Strata.			Depth from Surface.		
	Fm.	Ft.	In.	Fm.	Ft.	In.
Ironstone, C.B. ...	0	0	2½	236	1	5
Black Blaes ...	0	1	8½			
Coal...	0	0	1½	236	3	3
Black Blaes ...	0	0	2			
Coal...	0	1	0	236	4	5
Stone	0	0	2			
Coal...	0	1	6½			
Fakey Sandstone...	0	4	7			
Fakes	0	3	0			
Fakes and Blaes ...	0	1	5			
Coal...	0	0	2	238	3	2
Fakey Sandstone...	0	4	4			
Fakes and Blaes ...	0	3	0			
Coal...	0	0	3	239	4	9
Blaes	0	0	3			
Parroty Blaes ...	0	0	10	239	5	10
Blaes	0	0	7			
Parroty Blaes ...	0	0	1			
Coal...	0	0	2	240	0	8
Blaes	0	0	6			
Fakes	0	3	10			
Fake and Sandstone	0	1	8			
Sandstone... ...	0	2	6			
Fakey Sandstone...	0	1	10			
Fakes	0	3	6			
Fakes and Blaes ...	0	2	7	242	5	1
Parrot	0	0	1			
Coal...	0	1	5	243	0	7
Blaes	0	1	10			
Fakes	0	2	1			
Fakes and Sandstone	0	5	6			
Sandstone... ...	0	4	3			
Fakes	0	3	3			
Fakes and Sandstone	0	3	7			
Fakes	0	3	9			
Blaes	1	1	9			
Coal (Dunfermline Splint)... ...	0	3	9			
Sandstone... ...	0	3	6	249	3	10
Depth	249	3	10			

To the north of Saline Hill there is a coal-field of several thousand acres which is quite undeveloped. A railway was projected into this district by the North British Railway Company at the time the Caledonian Railway Company attempted to invade Fifeshire, but as the Caledonian bill was thrown out the North British Company did not require to proceed with their scheme, and the coal-field thus remains as a useful preserve for the future.

The outcrops of some of the Upper Saline Coals can be traced in the course of the Black Devon Water, which traverses the field from east to west.

The Black-band Ironstone has been worked in shallow pits near where the Devon Valley road crosses the stream, and its position has been traced by bores westward towards Sheardrum at depths varying from 12 to 24 fathoms.

Bores were put down about ten years ago to prove the district to the west of Saline village, but no workable coal-seams were met with in the first hundred fathoms, and the prospects of the district were not at that time considered sufficiently encouraging to warrant deeper bores to reach the Dunfermline Splint Coal.

The district between Saline Valley and Loch Glow has also been somewhat extensively bored. The boring, however, has not been carried to any considerable depth, but most of the shallow bores show coal-seams from 2 to 3 feet thick. A bore put down near the edge of Loch Glow passed through a number of thick seams, as shown in the following abstract:—

SECTION OF COAL-SEAMS FOUND NEAR LOCH GLOW

	Fms.	Ft.	Ins.
Strata	3	3	0
Coal 2 ft. 10 ins. Stone 0 ft. 2 ins. Coal 1 ft. 5 ins.	0	4	5
Strata	6	0	0
Coal	0	3	0
Fakey Fireclay	0	1	2
Coal	0	2	4
Strata	1	2	11
Coal	0	0	11
Strata	15	1	1
Coal	0	2	6
Coaly parting...	0	0	1
Coal	0	4	6
Fireclay	0	0	3
Coal	0	0	10
Strata	3	0	7
Coal, Rough	0	0	3
Coal, Parrot	0	0	2
Coal, Rough	0	1	0
Strata	1	0	5
Coal	0	2	9
Strata	2	3	4
Coal	0	4	1
Strata	18	0	0

These coals have not been found to extend throughout the rest of the district.

The volcanic rocks of the West of Fife district may be divided into two series, viz. tuffs, volcanic ash, and lavas which were ejected during the Carboniferous Limestone period, and are interbedded with the stratified rocks of that period; and dolerites and basalts (whins) which have been intruded into the strata in a molten condition at a much later period.

The volcanic rocks of the first class are similar to those of the Dalry coal-field described on p. 43, but with this difference, that at Dalry they are buried under accumulations of strata, and are only met with in the course of the underground workings, whereas, in the West of Fife district the overlying strata have been removed by denudation, and the volcanic rocks are now exposed at the surface in such a way that they may be examined in detail and their boundaries shown on the geological map.

The Saline Hills present a typical example of interbedded volcanic rocks. Their structure is very clearly shown in the section, fig. 6, which is taken from the Geological Survey memoir.

As already mentioned the coals are being worked underneath the volcanic ash and tuff, and are not affected by their proximity to it.

The central portion of the hill is occupied by a neck or plug of basalt about ¼ mile long by ⅛ mile broad. This neck probably represents the vent of the volcano through which the ash and detritus were ejected. The coal-workings have not yet approached the centre of the hill, but it will probably be found that the seams are burnt and destroyed all round the basalt neck.

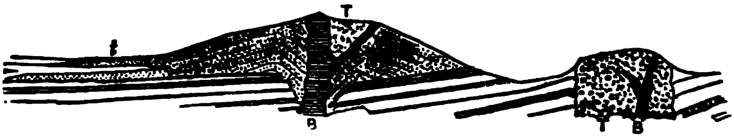


Fig. 6.—Section across the Saline Hills, Fife

The thick parallel lines mark the positions of the seams of Coal and Ironstone of the Saline field; some of them have been worked under the margin of Saline Hill. T, Tuff of the necks. *t*, Tuff at a little distance from the vent, stratified and interlaminated with ordinary sediment. B, Basalt. The larger eminence is Saline Hill, the smaller is Knock Hill.

The volcanic tuff has generally a stratified appearance, and consists of layers of finely-bedded green ash with bands of coarser material and volcanic conglomerate. Full details of this interesting geological feature are given in the memoir above referred to.

The intrusive igneous rocks of this district are similar to those found in the other Scottish coal-fields. There are many sills or "floats" underground which do not come to the surface, but the district has not yet been sufficiently explored to permit of their being traced in any continuous zones. In the Blairhall bore beds of whin amounting in the aggregate to over 40 fathoms in thickness were passed through. At about 200 fathoms from the surface a post over 17 fathoms thick was met with, and there is another post, 19½ fathoms thick, between the Dunfermline Splint and the Stinking Coal.

Between this bore and the town of Dunfermline several patches of whin are found at the surface cropping out below the Splint Coal; and the Roscobie Hills, 2 to 3 miles farther north, are composed of whin occupying a similar stratigraphical position. Future developments may prove that these outcrops are connected with the whin post underlying the Dunfermline Splint Coal in the Blairhall bore. At Kinedder (Oakley) and Saline Valley some of the lower seams have been converted into valuable steam coals by the action of the whinstone, and in some cases the coal has been either destroyed altogether or converted into anthracite.

THE LOCHGELLY COAL-FIELD may be taken as embracing the whole area between the Dunfermline and Kelty fields and the Cardenden and Kirkcaldy fields, next to be dealt with. To the south-east of Lochgelly the coal-seams crop out, and are succeeded by the Burntisland Calciferous Sandstones with their associated igneous rocks. On the north the Glencraig and Bowhill Collieries may be taken as the boundary. Beyond these collieries the Limestone measures are found dipping beneath the Coal-measures of the Kinglassie basin. As previously remarked, the Lochgelly area is comparatively free from volcanic intrusions, the whinstones of Kelty and Halbeath having apparently come to the surface to the west of this district. At Dalbeath the whole of the seams down to the

Splint Coal have been found close to the volcanic eruption of the Hill of Beath, and the workings are now extending westward underneath the hill. Towards the north there is an outburst of basalt rocks, but these appear to have been intruded in a horizon above the Index Limestone.

The most remarkable feature of the Lochgelly coal-field is the way in which the coal-seams have been folded into a series of troughs or waves, so that the outcrop of the same seam is repeated over and over again. The levels driven in the coal-workings circle round in all directions. There are also a number of faults traversing the field in a west-north-west direction, whereby the irregularity in the position of the coal-seams is further increased. Fig. 7 illustrates the general section of the coal-field. The fig. is taken from the Geological Survey memoir, and shows a section along an east-and-west line a little south of Lochgelly village.

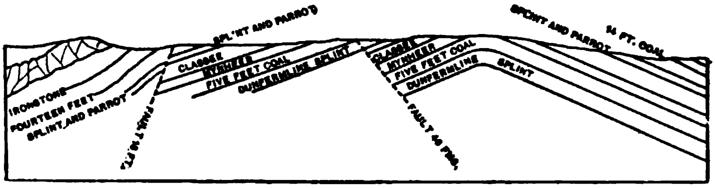


Fig. 7.—Section across the Lochgelly Coal-field from South Lumphinnans on the west to near Lochgelly House on the east

The Lochgelly coal-field was first opened up for the working of the Black-band Ironstone. The furnaces near Lochgelly station were in blast from 1847 to 1875, when operations ceased owing to the exhaustion of all the local ironstone which could profitably be dealt with. There were also iron furnaces at Lumphinnans, and these, too, are dismantled.

The ironstone-seam averaged 2 feet in thickness, but the quality was not exceptionally good.

At present the only ironstones being worked in Fifeshire are the Blairhall Ironstone and the ironstone from a band about 6 inches to 8 inches thick on the top of the Five-foot Coal. This latter is found at Halbeath, Hill of Beath, and Dalbeath, and it is smelted at the Lanarkshire furnaces. The output of ironstone in Fifeshire during the year 1900 was 30,706 tons.

The coal-seams have been more vigorously developed since the exhaustion of the ironstone, and the district is now producing a very large coal output.

The general section of the coals found here is given on Plate XIII.

The lower seams, from the Dunfermline Splint to the Glassee, resemble the corresponding coals in the adjoining Dunfermline field; but the Dunfermline Splint Coal is hardly so good here as at Dunfermline, and it seems to die out altogether farther to the east. The Lochgelly Splint and Parrot Seam has the following sections:—

SECTION AT LOCHGELLY COLLIERY

	Ft.	Ins.
Coal	0	6
Clod	0	9
Coal	6	3
Shales or Sandstone, varying from 2 ft. to ...	12	0
Parrot Coal, varying from 6 ins. to	4	6

SECTION AT COWDENBEATH AND LUMPHINNANS COLLIERIES

	Ft.	Ins.
Foul Coal	2	0
Splint Coal	5	0
Cherry Coal	0	6
Fireclay ... ... 0 to	3	0
House Coal (Doggar) ...	0	6
Parrot Splint	0	9
Parrot Coal	2	0
House Coal (Rough) ...	1	3

When there is sufficient parting between the Splint and Parrot Coals they are worked on the double longwall system. In working the coal care has to be taken to prevent the outburst of gob fires, as the seam is very liable to spontaneous combustion.

The Little Splint, Fourteen-foot, and Duddy Davie seams are workable subjects, but their quality is not very good. They are mostly used as second-class steam coals. Undernoted is an average section of the Fourteen-foot or Jersey Coal, which is worked double longwall.

		Ft.	Ins.
Second Working.	Coal	1	6
	Coaly Strains	0	5
	Fakey Blaes	0	11
	Coaly Blaes	0	2
	Coal, with partings	3	4
	Rib	0	1
	Coal	0	4
	Blaes	3	0
	Sandstone	0	6
	Fireclay	3	0
	Coal	0	4
First Working.	Bands	2	0
	Falling	0	1
	Coal, with partings	2	2
	Parting	0	1
	Coal	0	5
	Rib	0	1
	Coal	1	7

At Hill of Beath a seam of fireclay 15 inches thick is worked along with the Fourteen-foot Seam, and used for the manufacture of pipes, firebricks, and sanitary goods. The seams above the Lochgelly Black-band Ironstone have not been worked.

The northerly extension of the Lochgelly seams has been satisfactorily proven by the sinkings at Bowhill and Glencraig. At Bowhill the Lochgelly Splint is found at a depth of 170 fathoms, and at Glencraig at a depth of 200 fathoms. At Pitcairn, about ¾ mile north-east of Glencraig, a bore has been put down to the Lochgelly Splint Coal, which was found to be 8 feet 5 inches thick at a depth of 186 fathoms. The Capeldrae Gas Coal was passed through at 15 fathoms, and the other seams between the gas coal and Lochgelly Splint were found about the average thickness; but the thicknesses of the intervening strata are rather irregular.

The Lochgelly coal-field has always suffered from the large quantity of water met with in the workings, and very powerful pumping-engines have been found necessary at both the above-mentioned sinkings.

In the olden time the water at Lochgelly was drained by

PLATE XIV

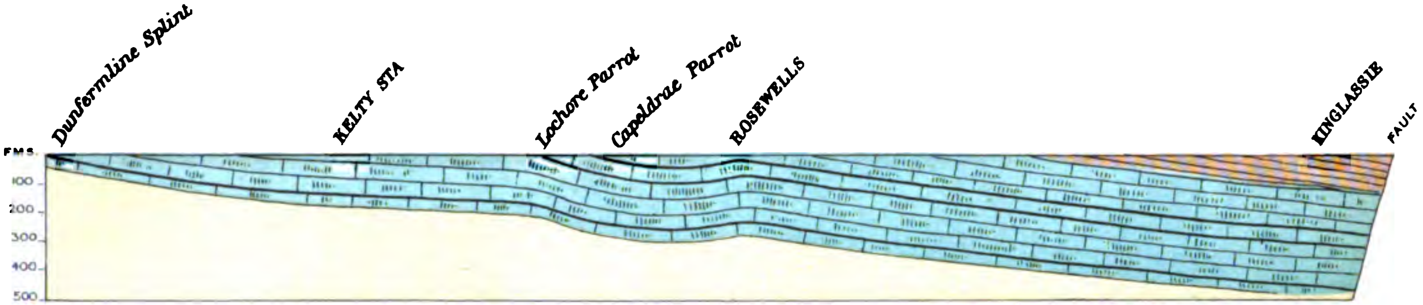


FIG. I

SECTION FROM KELTY TO KINGLASSIE

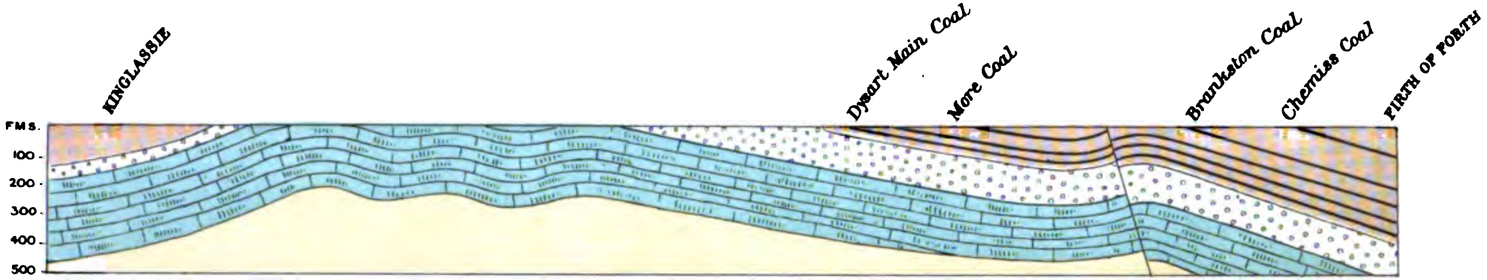


FIG. II

SECTION FROM KINGLASSIE TO WEST WEMYSS

means of a day mine which started from the River Ore at about the 200-feet level, and was driven southward for nearly a mile, thus draining the workings to a depth of from 15 to 30 fathoms.

To the north-west the Lochgelly coals dip into a basin under the River Ore, and their continuation is met with again on the other side, where they are found rising towards the Kelty pits. In this basin the series overlying the Index Limestone has been preserved from denudation, and several valuable seams of coal have been found between that limestone and the overlying Janet Peat and Levenseat Limestones. In the centre of the basin the Index Limestone is probably 200 to 250 fathoms deep, so that the Dunfermline Splint Coal is from 400 to 500 fathoms deep. No doubt this deep basin will be in the future a very important coal-field. A general idea of its structure may be obtained by drawing a line from about Kelty Station to a point about ½ mile north of Kinglassie, and continuing the line north-eastwards to the Leslie Branch Railway. This line represents approximately the bottom of the trough or syncline. The bottom of the trough becomes deeper going from Kelty towards Kinglassie, so that the Upper Coal-measures are found there occupying the centre, and forming the Kinglassie coal-field, which is described on p. 315. The depth to the Dunfermline Splint at the deepest part of the trough is evidently 500 to 400 fathoms. The sections on Plate XIV will illustrate this. Fig. 1 is a section along the above line from the Kelty to the Kinglassie coal-field, showing how the Upper Limestones come in, with the Lochore and Capeldrae Parrot Coals, and how these are overlain in turn by the Millstone Grit and Coal-measures. In fig. 2 is shown a cross section to the above from about Kinglassie to West Wemyss.

The coal-seams of the Limestone measures which crop out south of Clunie dip under the River Ore at an inclination of 1 in 6. Beyond Bowhill the inclination increases to

1 in 5 and 1 in 4, and they thus dip under the Millstone Grit and Coal-measures of the Kinglassie basin. The Limestone measures are found coming to the surface again on the north side of the synclinal axis, but any coal-seams which might be near the surface there have been destroyed by the basaltic intrusions.

At the Kelty end the trough flattens out, but its influence is seen in the curved shape of the outcrops of the various coal-seams, as shown on the Ordnance Survey geological maps.

The section of the coals in the Lochore and Capeldrae basin is as follows[1]:—

	Fms.	Ft.	Ins.
Craig Coal	0	4	6
Strata, of which more than one-half is whinstone, one band being 174 ft. thick	93	2	0
Capeldrae Parrot Coal, with Cherry and Foul Coal	0	4	4
Strata	6	1	6
Coal (with 7 ins. of Parrot and 2 ins. of Splint)	0	2	5
Strata	3	0	0
Capeldrae Ironstone	0	1	5
Strata, including some thin coals	46	4	0
Lochore Parrot Coal	0	2	2
Strata	3	0	0
Coal, splint	0	3	0
Strata, with some thin coals	30	0	0
Limestone (Index)	0	2	3
Strata	10	0	0
Parrot Coal and Black-band Ironstone ...	0	2	9
Sandstones, &c.	7	0	0
Coal	0	4	0
Sandstone	4	0	0
Coal	0	4	3
Sandstone and Fakes	1	3	0
Coal, Soft	0	3	0
Strata, chiefly sandstone	6	4	0
Black-band Ironstone (Lochgelly Seam) ...	0	2	3

The detailed sections of the Parrot Coals are given as below.

---

[1] Geol. Survey Memoir, pp. 138–139.

LOCHORE PARROT COAL

	Ft.	Ins.
Fakes and Fireclay Roof.		
Coal, Daugh	0	1
Parrot	0	11
Ironstone	0	1
Coal, Spratt	0	5
Ironstone	0	3
Coal, Spratt	0	3
Coal, Rough	0	3
Fakes and Sandstone Pavement.		

CAPELDRAE PARROT

	Ft.	Ins.
Black Shale Roof.		
Cherry Coal	1	2
Parrot No. 2	1	8
Parrot No. 1	1	6
Fireclay Pavement.		

A full description of the outcrops of these seams is given in the Geological Survey memoir.

The West Fife (Mineral) Branch Railway, which leaves the Kinross and Perth main line about 1 mile north of Kelty, passes through the centre of this coal-field, and continues to the Kinglassie coal-field. The Parrot Coals have been worked by numerous pits at the outcrops on either side of the basin, but the most extensive working was by the Lochore and Capeldrae Cannel Coal Company at Benarty Colliery, near Kelty. Unfortunately the workings have been rendered very expensive by the large quantity of water met with, and by the numerous whinstones, "wants", and "troubles". There are also a considerable number of faults running mostly north-west and south-east, and having a dislocation of from 20 to 60 fathoms.

As is usually the case with Parrot Coals, the quality of these seams undergoes considerable local alterations.

Instructive comparative analyses of the Lochore cannel coal and the Torbanehill mineral were made in 1876 by Mr. William Wallace of Glasgow. His report is given here in full:—

"On the 11th November, 1876, I visited the new mine belonging to the Lochore and Capeldrae Cannel Coal Company and took an average sample of the cannel coal, called by them Plesio Boghead, which was packed in a large box and forwarded to me by railway. On the 4th July last I visited five pits at which the Boghead coal (otherwise called the Torbanehill mineral) had been wrought, and from each I took several blocks, thus making up a fair average sample, which was sent on to Glasgow. I have analysed and tested the two coals, and in order to ensure uniformity in the results I used the same gas apparatus and made the trials on consecutive days and under precisely similar conditions. Three or four charges of each sample were distilled off, each charge weighing 22.4 lbs. The sample of Boghead cannel coal consisted of blocks from 9 to 22 inches in thickness, some of which had been exposed to the weather for years. Some time since I made a careful test of a large block of the same coal 22 inches thick, and as this gave a slightly higher result than the sample now tested, I give for comparison with the New Mine cannel the mean of the two analyses:—

ANALYSIS

		New Mine.	Boghead.
Volatile Matters.	Gas, Tar, &c.,	53·66	57·41
	Sulphur	.17	.19
	Water, at 212° Fahr.	2.60	.90
Coke	Fixed Carbon	33.81	10.07
	Sulphur	.16	.08
	Ash	9.60	31.35
		100.00	100.00
Volatile Matters, per cent		56.43	58.5
Coke, per cent		43.57	41.5
Coke, per ton (dry) in pounds		967	929
Coke, per ton, in cwts., qrs., lbs.		8:2:24	8:1:5

COMPOSITION OF THE COKE (DRY)

	New Mine.	Boghead.
Carbonaceous or Combustible Material	77.60	24.21
Sulphur	.37	.19
Ash	22.03	75.60
Specific Gravity of the Coal	1.225	1.264
Weight of a cubic foot in pounds	76½	78¾

PRACTICAL RESULTS

	New Mine.	Boghead.
Gas, per ton, at 60° Fahr. and 30° Bar.	13,165	14,900
Illuminating power in standard sperm candles by union jet consuming 3.5 cubic feet per hour, calculated to 5 feet per hour	36.16	42.19
Equivalent of a ton in pounds of sperm candles	1632	2157
Durability of 1 cubic foot by 5-inch flame	70 minutes	78 minutes
Gravity of the Gas (air = 1000)	618	685
Comparative value for Gas-making	75.6	100

"This cannel has many points of resemblance to the Boghead coal, which is now practically exhausted, and it will no doubt be largely employed, like it, for enriching gas made from inferior coals. In regard to the yield and quality of gas, its value is three-fourths that of Boghead cannel, while its coke, although of rather inferior quality, is not, like the Boghead, utterly useless, but may be employed for firing gas-retorts and other purposes to which the coke of cannel coal is usually applied. It resembles the Boghead coal in containing only a minute quantity of sulphur, rendering the purification of the gas simple and inexpensive."

Although the seams have been traced for a considerable distance towards the north-east, between Glencraig and Auchterderran, they are either burnt or too poor in quality to be worth working.

The other seams of coal shown in the section can hardly be looked upon as workable subjects apart from the Parrot Coals, and they have only been worked to a limited extent near the outcrops. A coal 3 feet thick was formerly worked near Auchterderran underneath the basalt, and a 4-foot coal was found under similar conditions a little to the north of Glencraig. A coal is at present being worked underneath the basalt of Benarty Hill.

A limestone is found in this section lying above the coals. It seems to occupy the horizon of the Levenseat or Castlecary Limestone. The Janet Peat Limestone and Coals do not appear to exist in this section of Fifeshire.

The fact that these upper coals have been so much interrupted by "whins", "wants", and "troubles" does not prove that the lower Lochgelly seams will be similarly interrupted. No doubt the principal faults will be found in the lower seams, but the basaltic intrusions are probably confined to the upper horizon and do not at all affect the lower coals, and the wants are, of course, local disturbances of the seam in which they occur. There is thus every reason to believe that a very valuable coal-field will be opened up here as soon as the commercial conditions warrant the large capital outlay which will be required for deep sinkings through the overlying basaltic rocks. A deep bore is being put down to the lower coals at a point about midway between Bowhill and Kinglassie.

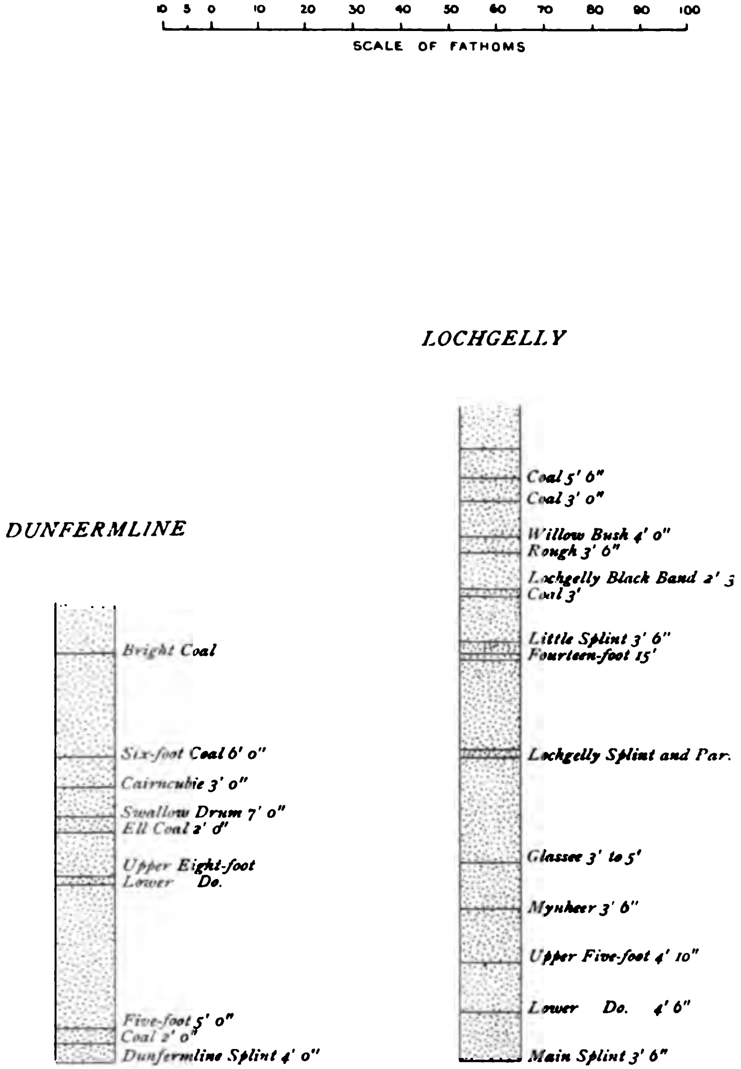
The apparent course of the intrusive igneous rocks has already been pointed out as rising upwards in the strata from Kelty until they are found above the Index Limestone in the Capeldrae field. In addition to those intrusive rocks there is also found a series of interbedded volcanic tuffs and lavas similar to those of the Saline Hills. These tuffs, &c., were erupted during the period when the Index Limestone and overlying strata were being laid down. They have not burnt the coal-seams, but they frequently cause the "wants" by occupying the position which the coal would have held under normal circumstances.

KIRKCALDY COAL-FIELD. — The principal geological feature of the Kirkcaldy coal-field is the occurrence of a great anticlinal axis. This is probably the continuation of the anticline of the Pentland Hills which divides the Carboniferous rocks of Edinburghshire from the Carboniferous rocks of Linlithgowshire. The probable course of the anticline across the Firth of Forth is indicated on the map, Plate IX. It reaches the Fifeshire coast about Burntisland, and runs from there in a north-north-east direction towards Markinch, where it seems to die out.

At Pathhead the coal-seams are found dipping to the east at an angle of about 1 in 3 underneath the Millstone Grit and the Coal-measures of the Dysart and Leven coal-field. Tracing the various outcrops inland, the dip is found to change first to north-east and then, at Clunie, to the north, at a very flat inclination. At Cardenden the dip is towards the north-west.

The various seams have been worked round the whole of this semicircle, and as the workings join with those of the Lochgelly coal-field there is no difficulty in determining the correlation of the different coals. The Lochgelly Splint

VERTICAL SECTION OF THE FIFESHIRE COAL



and Parrot Coals go under the name of the Black Coal and Parrot Coal. The Lochgelly Ironstone is found as a shale, with bands of rough coal and parrot coal. At Dundonald Colliery, which adjoins the Lochgelly coal-field, the seams worked are shown below, and the corresponding names by which they are known between that colliery and Kirkcaldy are also given.

	Ft.	Ins.		
Smithy Coal	3	0	=	Smithy Coal.
Lochgelly Ironstone	position			
Fourteen-foot Coal (Upper Leaf) ...	2	8	=	Splint and Rough or Clunie Coal.
Fourteen-foot Coal (Lower Leaf) ...	6	0		
Duddie Davie Coal ...	2	9		
Lochgelly Splint Coal	4	6	=	Black Coal.
Lochgelly Parrot Coal	2	9	=	Parrot Coal.
Glassee Coal	3	3	=	Cardenden Coal or Upper Smithy.
Mynheer Coal ...	2	9	=	Gibbs Hall Coal or Lower Smithy.

As the seams are now quite well identified, the local names shown in the second column are falling into disuse.

The Lochgelly Splint Coal is the best coal in the section, making a first-class household and steam coal. At Dundonald the Parrot Coal appears as a Splint Coal, but farther east it is found as a second-class Gas Coal, 2 feet thick. The Glassee and Mynheer Coals have become burnt with intrusive whins in the Kirkcaldy district, and are converted into steam and smithy coals of fairly good quality. The Dunfermline Five-foot and Splint Coals thin out in this direction, and have not been found as workable seams. At Dundonald there are two thin seams about 20 fathoms below the Mynheer, which may be the representatives of the Five-foot and Splint Coals, but they have not been traced east of that point.

The Kirkcaldy field is remarkably free from faults, and the bending of the strata over the anticline seems to have taken place without causing any fracture. The largest fault starts at the shore at Pathhead, and runs across the coal-field in a north-north-west direction, and is lost among the Calciferous Sandstones. The downthrow is to the south and probably amounts to between 50 and 70 fathoms. A 6-fathom fault, with downthrow to north, has been met in the workings of Dunnikier Colliery, and at Dundonald there are two faults running about east and west, with a downthrow to the north of 7 and 8 fathoms respectively.

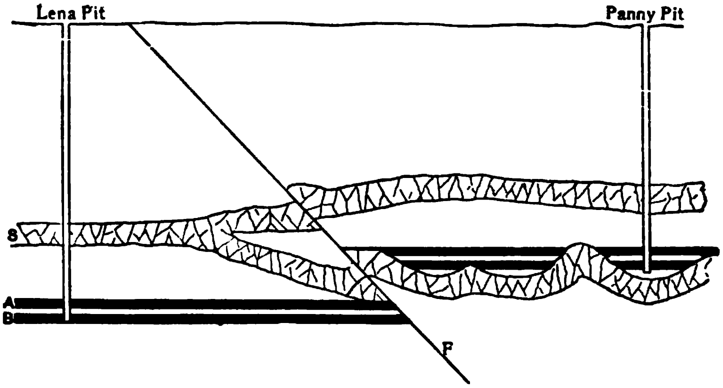


Fig. 8.—Section of Sill and Reversed Fault in the workings between the Panny Pit and the Lena Pit, Kirkcaldy

A, Black coal. B, Parrot coal. F, Reversed fault, six fathoms down to north. S, Sill.

There are a considerable number of intrusive whins about the horizon of the Lochgelly Splint and Parrot. A large mass of whinstone comes to the surface above those seams, south of Clunie, forming an escarpment about 100 feet high. The coals have been worked underneath the whin, and there are several old pits sunk through the whinstone. At Dunnikier the whin becomes thinner and splits in two, as shown in the section, fig. 8, which is taken from the Geological Survey memoir.

All the shallow coals are exhausted in the Kirkcaldy field, but the extension of those seams continues eastward underneath the Dysart field, and they have also been proven to the northward underneath the River Ore. During the last few years a number of deep bores have been put down in this northern extension of the Kirkcaldy coal-field. At Inchdairnie a bore was put down on the edge of the Millstone Grit, and reached the Lochgelly

Splint and Parrot at a depth of 157 fathoms. The Splint Coal was 3 feet 8 inches and the Parrot 3 feet 1½ inch thick, and the overlying seams were found in their normal condition. A coal 3 feet 2 inches thick was found at a depth of 182 fathoms, and the bore was continued to a total depth of 216 fathoms. South-eastward from that point there appears to be a progressive thinning out of all the seams. Bores put down towards the eastern edge of the coal-field at Skeddoway prove that all the seams become too thin to be worked before they dip under the Upper Measures of the Leven coal-field.

In the EASTERN DISTRICT OF FIFESHIRE there is an exposure of the Carboniferous Limestone series stretching from Markinch to Pittenweem, and extending northwards nearly to Cupar and St. Andrews. The total area of this coal-field is about 40 square miles—an area greater than that of the Dunfermline, Lochgelly, and Kirkcaldy coal-fields,—but the whole district is so much cut up by faults, intrusive igneous rocks, and irregularities of the strata, that mining is only being carried on to a very limited extent. The output of coal from the district during the year 1900 did not exceed 50,000 tons, and the great bulk of this output was for land-sale purposes.

The North-British Railway Company have constructed a branch line, known as the East Fife Central Railway, which passes through the district, and is designed to form a connection with their system to St. Andrews. In the meantime this railway stops short at Lochty, about 5 miles from St. Andrews, and, as it thus gives no connection with the northern markets, it is not of much use to those coal-owners who are carting their coals to St. Andrews and the surrounding villages.

Between Colinsburgh and Radernie there are several pits working on a small scale, and bores are also being put down at Lathallan and Cassingary, &c., with the view of opening up the coal-field on a more extensive scale. On account of the irregular basins in which the coal is deposited, and the limited extent of the workings, it is not easy to compile a general section of all the seams, but the following is probably a fair average:—

GENERAL SECTION OF LARGOWARD COALS

		Fms.	Ft.	Ins.
Rires Coal?	Coal	0	3	0
	Strata	14	3	0
	Coal	1	0	6
	Strata	4	0	0
	Coal	0	1	6
	Strata	2	0	0
	Coal	0	5	6
	Strata, unknown, probably about	20	0	0
	Coal ... Strata Coal ... Strata Coal ... Strata Coal ... — The Four Coals of Lathallan. The relative position and thickness of these coal-seams is not definitely known.	30	0	0
	Strata ... ... about	5	0	0
From Bores and Pits on Lathallan Estate.	Parrot Coal — Coal 14 ins. Blaes 3 ins. Coal 15 ins. ...	0	2	8
	Strata	3	0	0
	Six-foot Coal	0	4	1
	Strata	3	0	0
	Thin Splint Coal ... 22 ins. to	0	2	8
	Strata	2	0	0
	Thick Coal ... ... 39 ins. to	2	0	0
	Strata	1	0	0
	John Barnet's Coal	0	1	10
	Strata	22	0	0
	Marle Coal ... 2 ft. 8 ins. to	0	4	0
	Strata	10	0	0
	Little Coal or Little Splint 0 to	0	1	8
	Strata	6	0	0
	Whitemire Coal ... 6 ins. to	0	2	6
	Strata	23	0	0
	Limestone	0	1	10
	Strata	1	3	0
	Bastard Coal (foul)	1	1	0
	Strata	13	0	0
	Splint (Lathallan or Largoward)	0	4	0
	Strata	12	0	0
	Black Coal	0	3	0
	Strata	3	3	0
	Pilkem Coal	0	2	0
	Strata, probably about	200	0	0
	Lochty Coals (section, page 299).			

I cannot be sure if the Rires Coals overlie the "Four Coals of Lathallan", which are described in Dr. Landale's memoir, or if they are identical with those four seams. A bore put down in front of Lathallan mansion-house passed through four coals, from 18 to 33 inches thick, above the Parrot Coal, and these would correspond with the "Lathallan Four Coals". Further to the dip several seams have been passed through in shallow bores which either correspond with the "Rires Coals" or are seams which have not been mentioned in any previous records. So that if the "Rires Coals" and the "Lathallan Four Coals" are identical, there is a series of overlying coals occupying a position such as I have indicated on the foregoing section.

It is generally supposed that the Lathockar or Lathones Coals, of which a section is given on page 303, occupy a position below the Lathallan Splint Coal. There is no direct evidence to support this assumption, but the proprietors of Lathallan estate are at present putting down a diamond bore to prove the strata below the Splint Coal, and when that is completed it will settle this point definitely.

A short account is now given of the various districts in which these coals are found.

THE LOCHTY COAL-FIELD.—The coals in this area occur in a series of strata marked on the geological map as "Lower Carboniferous". These coals are found about 200 fathoms below the position of the Main or Hurlet Limestone, and would thus appear to occupy a horizon equivalent to that of the coals found in the Oil Shales or Burdiehouse Limestone series of the Lothians.

Along the coast from Pittenweem to Fife Ness the outcrops of the sandstones, limestones, and thin coal-seams, &c., of this series have been well exposed. From these beds many marine fossils have been obtained, such as *Archæocidaris*, *Bairdia plebia*, *Discina nitida*, *Bellerophon decussatus*, *Spiriferina cristata*, *Nuculana attenuata*, &c.,

which are characteristic of the strata between the Burdiehouse Limestone and the Hosie Limestone, but which are not found in the Burdiehouse Limestone or the beds directly associated therewith.

These fossils indicate that this series of strata have been laid down under marine conditions, unlike the freshwater beds of the Burdiehouse or Oil Shale series, but they may have been contemporaneous with the Burdiehouse series. It is interesting to note how the conditions favourable to the formation of coal-seams occurred so much earlier in the east of Scotland than in the west. These East of Fife coals were formed long before any coal-seams were deposited in the West of Scotland. The same circumstance has been already noted when tracing the coals both of the Coal-measures and the Carboniferous Limestone from west to east. No seams corresponding with the Lochty Coals are found in any other part of Scotland.

In Fifeshire the strata underlying the Hurlet Limestone, which have been exposed from Burntisland to Inverkeithing and near Loch Fitty, belong to the Burdiehouse type. No doubt the Lochty Coals extend for some distance westward below the Carboniferous Limestones of Largo and Largoward. It would be very interesting geologically if the westward extension of these coals could be traced until they meet with the Burdiehouse Limestone series, but unfortunately their quality is too poor to warrant any search for them at such a depth.

Along the coast-line only a few thin and impure seams of coal have been found, but the outcrops of several coal-seams can be traced inland from the boundary fault at St. Monans for a distance of 5 or 6 miles northwards towards St. Andrews. During recent years several attempts have been made to work the coals where they are accessible to the East Fife Central Railway at Lochty. Several bores have been put down there, but no pits have yet been sunk.

The sections found in the bores are as follows:—

SECTION OF LOCHTY COALS

	Fms.	Ft.	Ins.
Back Coal, with partings	0	7	10
Strata	26	0	0
Fore Coal	0	3	4
Strata	16	0	0
Coal	0	1	0
Strata	5	0	0
Coal	0	0	11
Strata	11	0	0

SECTION OF BACK COAL

	Ft.	Ins.	Ins.
Coal	0	9	
Stone			1
Coal	1	0	
Fireclay			6
Coal	2	3	
Coal and Sulphur ...	0	6	
Coal	0	8	
Fakes			1
Coal	0	9	
Fakes			1
Coal	1	2	
	7	1	9

SECTION OF FORE COAL

	Ft.	Ins.	Ins.
Coal	0	6	
Stone			½
Coal	1	3	
Fakes			1
Coal	1	6	
	3	3	1½

In Dr. Landale's report on the East of Fife coal-field this section is described as the "Kellie Coals". He states that the *fore coal* varies in thickness from 4 feet 6 inches to 7 feet, and that the roof is composed of hard shell limestone 3 feet thick. The roof of the *back coal* is described as a "hard black bituminous slate, of a peculiar character, seeming to resist the action of the weather for a long time". Dr. Landale also mentions that he has traced the outcrops of two coal-seams underlying the *fore coal*. One of these seams is given as 2 feet 4 inches thick. He also mentions a seam of splint coal, 3 feet thick, above the *back coal*.

The two thin seams shown on the above section may be the lower seams that Dr. Landale mentions, but there is no trace of the upper seam in any of the recent operations.

THE LARGO, LARGOWARD, AND RADERNIE COAL-FIELD embraces the district stretching from Kirkton of Largo and Colinsburgh northwards to Radernie. About 50 per cent of that area is covered by igneous rocks, but these do not interfere with the working of the coals so much as might be expected. In some cases pits have been sunk through the whinstone and the coal found uninjured beneath, and in other cases the underground workings have been carried below the whin, as at Kilbrackmont Crags and Gilston, without interruption. There are numerous volcanic necks in the district, of which Largo Law is a notable example, and of course the coals are destroyed where these necks have burst through.

There are at present no coal-workings in the southern part of the district between Colinsburgh and the coast, nor are there any workings between Colinsburgh and the East Fife Central Railway. The only record of which I am aware containing any account of the coal-seams in the vicinity of Colinsburgh is Dr. Landale's memoir on the East Fife coal-field. He describes a small trough of coal lying between Balcarres Hill (½ mile north of Colinsburgh) and Kilbrackmont Crags. The trough does not measure more than 800 yards across, and is about 50 yards deep. The section of the coals is:—

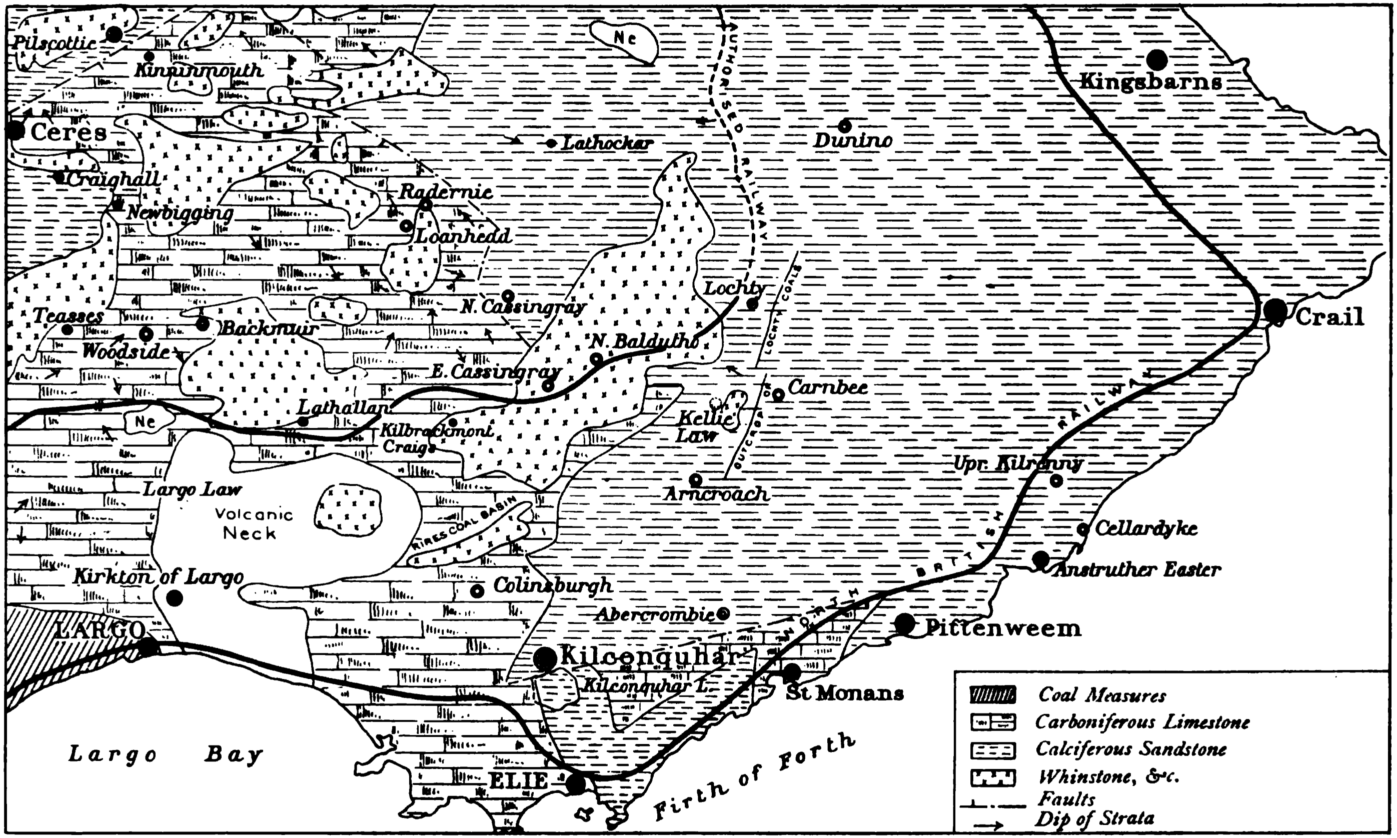
	Fms.	Ft.	Ins.
Coal	0	3	0
Strata	14	3	0
Coal, not all good coal	1	0	6
Strata	4	0	0
Coal	0	1	6
Strata	1	0	0
Main Coal, with 14 ins. of black slate ...	0	5	6

These coals appear to have been worked out prior to the date of Dr. Landale's memoir (1834) and are of historical interest only. There is no record of any coal-workings south of Colinsburgh. The Geological Survey shows the supposed outcrop of the lower limestone a little to the west of Kilconquhar, and it seems rather strange that none of the overlying coals have been found.

In the LARGO WARD DISTRICT there are several small collieries at work, the coal being mostly disposed of by land sale.

The splint coal known as the Largoward Splint Coal

GEOLOGICAL MAP OF EAST FIFE Scale—2 miles to an inch



(section p. 296) has been more extensively worked than any of the other seams. On Lathallan estate a pit was sunk to this seam at a depth of 80 fathoms, and all the coal available from that sinking worked out. While the pit was working, the output was about 200 tons per day, and this was disposed of by cart sale. Although the other seams were passed through in the shaft and some attempt made to work them, it was found that there was no local demand for soft coal, even at a lower price, so long as any of the splint coal was available. At Drumhead a pit was working the splint coal within the last few years. The section of the working was:

	Ft.	Ins.
Blaes, roof		
Coal	0	6
"Pelt"	0	6
"Rumm"	1	0
Coal	3	9

"Pelt" and "Rumm" are local names given to bituminous shale with films of coal, sometimes passing into parrot coal. There is no market for this substance for land sale purposes, and in the Drumhead workings it increased in thickness, taking the place of the upper portion of the coal, and thus diminishing the commercial value of the seam. The Black Coal was also worked at Drumhead, but only to a very limited extent. One of the upper seams, probably the first splint coal in the section, was worked recently on Lathallan and was of very good quality. A recent bore on Lathallan estate found the section of the "Thick Coal" as follows:—

	Ft.	Ins.	Ft.	Ins.
Coal	1	9		
Parting			0	3
Coal	1	6		
Parting			0	2
Coal	1	0		
Fireclay			1	6
Coal	1	0		
Fireclay			3	8
Coal	1	2		
Fireclay			0	6
Coal	0	10		
	7	3	6	1

In 1859 a bore was put down on the lands of Cassingray, just beyond the outcrop of the Largoward Splint Coal. At a depth of 62 fathoms a Black-band Ironstone, resting on 1 foot 9 inches of hard coal, was met with, and 1 fathom below there was a hard splint coal 2 feet 9 inches thick. Farther east, at North Baldutho, some coals have been worked below the trap, one of which was said to be 4 feet thick.

Between Baldutho and Colinsburgh there are traces of old pits along the base of Kilbrackmont Crags. Dr. Landale mentions four seams which were worked. He does not give the distance between the seams, but describes them as follows (p. 299): "A is 6 feet thick, and said to be splint; B is named the Two-foot Splint, C the Three-foot Coal, and D is called the Marl Coal. This latter is divided into two; the lower stratum is 3 feet thick, and the upper 2 feet and very soft. There is a bed of soft argillo-arenaceous marl between them, hence its name 'Marl Coal'. E the limestone, 14 feet thick." There is a tradition that a pit was sunk through the trap at Baldutho, and that a splint coal, supposed to be the Largoward Splint, was worked to a small extent.

There appears to be little doubt that several of the coal-seams pass under the whinstone composing Kilbrackmont Crags, and boring and mining operations which are at present being conducted will show to what extent the coals have been affected by the whin.

A large fault, running north-west and south-east, cuts off the coals on the northern side of the Kilbrackmont Hill at South Cassingray farm. About 1 mile north-west of that farm coals are found again on the rise (or north-east) side of the fault, forming the Lathones and Lathockar basin. Although the Lathones coals are separated from the Lathallan coals only by the single fault, the seams worked here have not yet had a definite position assigned to them in relation to the Largoward section.

The seams are known as the Cherry Coal, the Main Coal, the Duffie Coal, and the Brassie Coal. They are all between 3 and 4 feet thick. Underlying the Brassie Coal there is a seam of limestone 9 feet thick. A bore was put down recently beyond the outcrop of the limestone, and the strata met with was reported to be quite different from the strata associated with the coal-seams. It would therefore appear that the limestone corresponds to the Hurlet or Hosie Limestone, and the Brassie seam to the Dunfermline Stinking Coal, and that seam is probably the same as the "Pilkem Coal" of the Largoward section. On the Ordnance Survey geological maps the Carboniferous Limestone measures are shown to be cut off by a large upthrow fault, running about parallel with the above-mentioned fault, and about ½ mile east of it. Some coals have been worked to the east of the fault, and tradition says that they were the Lathones coals. This is in the area coloured as Calciferous Sandstone on the Geological Survey map, but, if the tradition is correct, the boundary of the Carboniferous Limestone series should be shifted nearly 1 mile farther east, so as to include the area containing these coals.

SECTION OF LATHOCAR COALS

	Fms.	Ft.	Ins.
Cherry or Marl Coal	0	3	0
Strata	1	5	0
Main Coal	0	4	6
Strata	4	0	0
Duffie Coal ... ... 2 ft. 6 ins. to	0	3	8
Strata	4	0	0
Brassie Coal	0	3	0
Strata ... ... about	10	0	0
Limestone	1	3	0

Along the northern margin of the coal-field between Ceres and Drumcarrow there are many traces of old coal-workings, but nothing has been done here within recent years. The following section of the Ceres coals is copied from Dr. Landale's paper. None of the coals were being worked at the time that paper was written, and Dr. Landale states that so long a time had elapsed since the coals were wrought that there were few living who knew anything about them. The section was taken by him from an old report.

SECTION OF STRATA CONNECTED WITH CERES COALS

			Rocks.		Coals.	
			Yds.	Ft.	Ft.	Ins.
1.	Luncart Coal				4	3
2.	Shale and Soft Sandstone		20	0		
3.	Make-him-rich Coal	Wrought as one seam			3	0
4.	Shale		0	2		
5.	Two-foot Coal				2	0
6.	Sandstone and Shale		60	0		
7.	The Thick Coal—thickness variable, average				16	0
8.	Sandstone and Shale		12	0		
9.	Four-foot Coal				5	0
10.	Metals, very hard		6	0		
11.	Six-foot Coal				6	0
12.	Metals, passable		10	0		
13.	The Little Splint				2	6
14.	Metals		13	0		
15.	Bowanton Coal				3	0
16.	Hard Stone		8	0		
17.	Donaldson Coal				1	6
18.	Hard Sandstone		14	0		
19.	North Coal				3	0
20.	Sandstone and Shale		8	0		
21.	Little Coal				2	6
22.	Sandstone and Shale		5	0		
23.	The Five-foot Coal—2 ins. of stone in it				4	6
24.	Sandstone and Shale		2	0		
25.	The Four-foot Coal				4	0
26.	Metals, passable		18	0		
27.	The Whin Coal, with 2 ins. of black clay slate in it				4	0
28.	Metals		2	0		
29.	The Rum or Foul Parrot Coal				3	0
30.	Metals, passable		70	0		
31.	The Black Coal				2	6
32.	Metals		—			
33.	Ballfield Coal				2	6

This shows a total thickness of over 69 feet of coal. The Geological Survey maps show a Five-foot Lime and Ironstone below the Black Coal, and below that the Lower Limestone.

Dr. Landale says: "These coals will some time or other be highly prized and yield a very handsome return, but in the present glutted state of the market a complicated coal-field cannot be worked to advantage".

About 1½ mile south-east of Ceres the Lower Limestone is being worked at Newbiggin of Craighall, and coal is obtained from a pit sunk through the whinstone about ½ mile to the east of the limeworks.

There are some small coal-workings farther south at Teases and Baldastardo, but the coal appears to be foul and burnt, especially near the trap. There are two seams, the first, 2 feet thick, containing 1 foot of parrot coal and 1 foot of cherry coal. The other is 4 feet 10 inches thick, but contains 14 inches of fakes.

BURNTURK AND MARKINCH.—There is a small and unimportant coal-field at Coaltown of Burnturk and Rameldry, about 2 miles south-east from the village of Kettle.

The available coals are practically exhausted, but there are still two pits going a little south of Rameldry. The coal is all used for local purposes, principally for lime burning. The section of these coals is:

	Fms.	Ft.	Ins.
Upper or Main Coal	0	3	6
Strata	10	0	0
Smithy Coal	0	1	9
Strata	6	0	0
Parrot Coal, with 2 ins. of soft parrot ...	0	4	2

The coals appear to crop out to the south of Rameldry, but at Carriston, about half-way between Rameldry and Markinch, a blind coal 4 feet thick was wrought many years ago. What is probably a continuation of the same seams was also worked near Markinch. The section of the Markinch Coals is as follows:—

	Fms.	Ft.	Ins.
Craw Coal	0	1	6
Freestone	10	0	0
Little Coal	0	1	6
Strata	3	0	0

	Fms.	Ft.	Ins.
Main Coal	0	4	9
Strata	7	0	0
Under Coal	0	1	10
Fireclay	2	0	0

These coals occupy a trough lying to the west of Markinch. The eastern edge of the trough appears to stretch north-eastward through the village of Star, in the direction of Carriston. On the western outcrop the inclination becomes less, and the coals have been traced for some distance towards the igneous mass of the Lomond Hills. The Main Coal, which is believed to represent the Dunfermline Splint, was wrought out long ago. There are some areas of the other three thin seams still unworked. These may be opened up in the future, but in the meantime they are of no commercial importance.

At Kilmux, about 1½ mile north-east of Kennoway, some coals were also worked early in the century. Dr. Landale mentions four seams.

A. Six feet thick.
B. Four feet nine inches thick.
C. Two feet two inches thick, with a bed of slate clay in it eight inches thick.
D. Two feet two inches thick, with eight inches of bituminous slate ("rumm") in it.

The coals dip towards the south-east at an angle of 6°, and may extend for some considerable distance in that direction. As the East Fife Central Railway now passes through the centre of the field, there is some inducement to prove it further by boring. The old coal-workings were carried to a depth of at least 58 fathoms, and were drained to that depth by means of a day level. According to local tradition they were of very good quality.

THE ST. MONANS AND PITTENWEEM COAL-FIELD.—The following section of the St. Monans and Pittenweem Coals is taken from Dr. Landale's paper. The thickness of the limestone and coals is measured at right angles to the plane of their beds, while the other rocks are measured along the line of section as they occur on the shore.

SECTION OF STRATA CONNECTED WITH THE ST. MONANS AND PITTENWEEM BASINS

	LIMESTONE.		COAL.		ROCKS.	
	Ft.	Ins.	Ft.	Ins.	Yds.	Ft.
1. Sandstone, with some beds of shale resting on the trap of St. Monans Church					50	0
2. The Suttie Limestone, compact, of a dark bluish-gray colour, few organic remains	10	0				
3. Shale, with bands of ironstone, from 2 to 4 ins. thick					6	2
4. Schistose Sandstone, with partings of slate-clay					6	1
5. Slate-clay, with nodules of ironstone ...					6	2
6. The White Limestone, containing encrinites and marine shells, of a whitish gray colour and compact texture ...	16	0				
7. Shale, with alternations of schistose sandstone and inch bands of ironstone					20	0
8. White Lime Coal			2	0		
9. Shale					0	2
10. Abercrombie Limestone	2	6				
11. Alternations of Shale, Slate-clay, and Sandstone, with irregular masses of ironstone, with *Terebratula*					9	1
12. Abercrombie Coal			4	0		
13. Alternations of Slate-clay, black Bituminous Shale, and Sandstone... ...					6	2
14. Pilkembrae Limestone, compact, gray colour, no organic remains seen ...	6	0				
15. Shale, Slate-clay, bands of Ironstone, and thin films of Sandstone					60	2
16. Little Limestone	2	10				
17. Regular alternations of Shale and Sandstone, in thin beds, with some ironstone bands					61	2
18. Sandstone, with slate-clay partings ...					46	2
19. Shale					1	1
20. Harbour Coal			6	0		
	37	4	12	0	276	2

"This mass of strata is now bent like the section into a basin form, the 'Harbour Coal' forming a little trough, which is the fair-way into St. Monance harbour. . . . After having spent a considerable time in exploring this quarter, I made a search for the descendants of the managers of the Pittenweem Colliery (which has been standing for many years), and most fortunately got a sight of a collection of old plans which have thrown much light upon the subject. Among the rest a curious old document was discovered entitled 'A view of the sea rocks at and east of St. Monance at low-water,' . . . and it was from this I obtained the local names I have used. This interesting paper seems to have been well handled, and, to add to its curiosity, there is a copy of a tavern bill on the back of it, partially erased, and if we may judge by an item for breakage, the old geologists must have made merry over it. As we proceed inland we find other eleven seams of coal occupying the interior of the basin, and they also all unite at a point like the St. Monance seams. . . . Within a space of 35 feet there are found the first four of the Pittenweem seams. They are named the 'Four Plies', I should think from their being so near each other. . . . About 50 feet from the 'four plies' we find the 'mid coal', and 30 feet from this we find the 'fore coal', which is the first of the 'six coals', and are all included in a distance of 150 feet. These coals have been wrought to a depth of 76 yards, and the bottom of the trough or synclinal axis of 'My Lord's Coal', 'Foul Hose Coal', and 'Brassie Coal' passed over, so that there can be no doubt but that all the other coals and limestones pass under them. The second, or St. Monance basin, is only known to contain the 'Harbour Coal' and the two seams accompanying the 'White and Abercrombie Limestones'. I should think, however, that if proper search were made, two other coals would be found under it, as it is probable that the 'Harbour Coal' is the St. Monance thick coal bent in here, and the anticlinal axis abraded off. . . . The St. Monance Coals were lately wrought, and the workings proceeded as far north as the county road, where they got thinner and flatter, and their line of bearing gradually turned round in a north-westerly direction. Crops of coals were seen up-country, near Abercrombie, which were supposed to be the St. Monance seams."

In a map of the coal-fields of the district Dr. Landale gives the seams as follows:—

			Ft.	Ins.
White Lime Coal			2	0
Abercrombie Coal			4	0
Three-foot Coal	St. Monans		3	0
Four-foot Coal			4	3
Wick Coal		variable	10	0
Thin Coal			uncertain	
Lower Coal	Pittenweem		5	0
Third Ply			4	0
Second Ply			5	0
First Ply			5	6

Some information regarding the old workings at Pittenweem is given in the *Annals of Pittenweem*, in which the following minute of council and note is found:—

"Pittenweem Coal—10th August, 1771—An agreement entered into between the town and Sir John Anstruther as to shipment of coal, &c.

"*Note.*—At this time a company was started under the firm of the 'Newark Coal Company' to work the Pittenweem Coal. Sir John Anstruther, who was a leading shareholder, entered into an agreement with the town to form the basin at the harbour, erect new quays, and rebuild a great part of the old pier, which had been beat down by a storm, in consideration of certain privileges being granted for the shipment of coal and salt. Upwards of 300 men were employed at the mines, and considerable quantities of the mineral were exported to Holland and elsewhere. An impost of ¼*d.* per ton, payable to the town on the coal, salt, or other materials imported or exported by the company, was let for a year by roup at £8, 5*s.* sterling, which, without taking into account the taxman's profit, would indicate an import and export of about 8000 tons annually. This company seems to have given up working the coal in 1794. Although the Pittenweem Coal had been wrought prior to the Reformation there is no mention in the Council records of its having been exported until the formation of this company. The right to the coal in certain lands within the burgh belonging to Anstruther of Balcaskie formed the subject of a law-suit about the end of last century between him and Anstruther of Elie. Both the Court of Session and the House of Lords decided in favour of Anstruther of Elie."

About 1890 the council of Pittenweem made an effort to get the coal-field opened up, so as to bring more trade to the district, but their efforts did not meet with success.

THE COAL-MEASURES.—In Fifeshire the Coal-measures are found in two areas in the eastern part of the county, viz. in the Leven and Dysart coal-field and in the Kinglassie coal-field. The sections on Plate XIV show the relationship between these two coal-fields. There can be no doubt that they were originally coterminous, but along the anticline from Burntisland to Markinch the strata in the intervening space have been uplifted and subsequently denuded, so that the coal-field now takes the form shown in the section (fig. 2, Plate XIV).

The Leven and Dysart field takes the form of a triangle, having as its base the coast-line from Dysart to a point about 2 miles north-east of Leven. The northern boundary is formed by the continuation of the east-and-west fault which cuts off the Kinglassie coal-field. At Markinch that fault has an upthrow to the north of sufficient extent to throw the Calciferous Sandstones opposite the lower beds of the Coal-measures, thus representing a displacement of at least 250 fathoms. Towards the east it becomes smaller, and at the coast, near Leven, the displacement does not exceed 90 fathoms. At that point there are also two parallel faults about ½ mile and 1 mile respectively to the north of the great fault, and these latter form the boundary of the coal-field. Those three faults seem to join one another before reaching the eastern shore of Largo Bay. They also join with another fault which passes under the water at Buckhaven, and the combined faults then form one line running north-east-east through Kilconquhar and Pittenweem.

The western boundary of the Dysart and Leven field is formed by the outcropping of the Coal-measures along a line from Dysart to Markinch. The area of coal-field thus described is 18½ square miles. The coal-field also extends for some distance underneath the sea, and probably connects with the Edinburghshire coal-field as found on the south side of the Firth of Forth, about 14 miles distant.

In a narrow strip along the coast the Coal-measures are overlain by the Upper Red Sandstones. The section from the top of the Upper Red Sandstones to the base of the Coal-measures is as follows:—

	Fms.	Ft.	Ins.
Upper Red Sandstones ... ... about	150	0	0
Coal-measures Strata	45	0	0
Wall Coal	0	3	0
Strata	16	4	0
Barncraig Coal or Leven Eight-foot Coal	1	0	0
Strata	14	1	0
Upper Coxtool Coal or Leven Six-foot Coal	0	2	6
Strata	5	0	0
Lower Coxtool Coal...	0	3	0
Strata	6	0	0
Den Coal	0	2	0
Strata	20	0	0
Chemiss Coal or Leven Main Coal ...	1	3	0
Strata	10	0	0
Bush Coal	0	3	9
Strata	58	2	0
Parrot Coal	0	3	3
Strata	6	1	0
Wood Coal	0	3	0
Strata	6	1	0
Earls Parrot Coal or Wemyss Parrot Coal	0	2	0
Strata	7	5	0
Bowhouse Coal	1	1	0
Strata	7	0	0
Brankstone Coal	0	2	6
Strata	9	3	0
More Coal	0	1	9
Strata	13	2	0
Mangie Coal (Balgonie Splint)	0	2	4
Strata	3	4	0
Sandwell Coal	0	1	3
Strata	33	2	0

		Fms.	Ft.	Ins.
Dysart Main Coal, with partings		3	1	2
Strata		12	3	0
Seven-foot Coal	3 ft. to	1	0	7
Strata		33	2	0
Millstone Grit Series.				

This section shows seventeen separate seams, with a total thickness of over 74 feet of coal. Comparing these coals with the coals of the Lanarkshire section, the seams from the Barncraig to the Chemiss would correspond with the seams from the Ell to the Splint. From the Bush Coal to the Bowhouse or Mangie corresponds with the Lanarkshire Virtuewell to the Drumgray, and the seams below the Mangie correspond with the Armadale seams.

The seams at present being worked are the Barncraig, Coxtool, Chemiss, Earl's Parrot, and Dysart Main. More than half of the total thickness of coal in the section is comprised in these fine seams.

The Barncraig Coal, known locally as the Eight-foot Coal, varies in thickness from 5 feet to 6 feet 9 inches. It is principally used as a steam coal, and sometimes as a house coal. A foot of the coal is generally left on to support the roof.

The Coxtool is also a steam coal. The section is:

	Ft.	Ins.
Coal	1	6
Stone	0	8
Coal	2	3

The Chemiss Coal contains the following subdivisions:—

		Ft.	Ins.
Crow Coal (not worked)		1	0
Parting		0	1½
House Coal (very good quality)	3ft. 6 ins. to	4	6
Parting		0	1
Binks Coal (steam)		2	4
Stone	8 ins. to	1	0
Coal (steam)	1 ft. 6 ins. to	2	6
Fireclay			

This seam is worked on the double longwall system. It is very liable to spontaneous combustion, and to obviate this the workings are divided into small panels which can be shut off at once from the ventilating current on the appearance of any fire. At Buckhaven the upper lift of the seam is of exceptionally good quality. At Wemyss the workings in the Chemiss Coal have been carried under the sea for a considerable distance, at a level of 90 fathoms below high-water mark. At Buckhaven the undersea workings in the same seam extend for over ⅓ mile, and it is found there that the dip is decreasing and the quality of the coal improving as the workings extend seaward.

At Leven the Chemiss Coal becomes foul and troubled under the sea, as shown by the following quotation from the Geological Survey memoir (p. 156). "At the Leven Collieries . . . nearly all the dip workings are (and have been for years) in very foul stuff—bits of stone where the coal should be, then a patch of coal perhaps full height, perhaps not, time after time, just as though a very flat hitch, or a reverse fault, or a thrust on a large scale, had continued in the coal over a large area. And at the Durie Colliery, farther to the east, the same coal is found rising to the east (instead of dipping), and so foul that it has never been worked."

The Earl's Parrot Coal is a gas coal of fairly good quality, and is being worked at Wemyss and Buckhaven. It varies in thickness from 18 inches to 3 feet. At West Wemyss it consists of 14 inches of parrot coal and 14 inches of rough coal. The workings at West Wemyss extend undersea for more than ½ mile. At Leven most of the lower portion of the seam is cannel, and the thickness of cannel is from 2 feet 2 inches to 2 feet 9 inches.

The Dysart Main Coal exists throughout most of the area, and on account of its thickness and quality has been very extensively worked.

The partings in the seam and the thickness of dirt vary considerably, as shown by the following sections:—

SECTIONS OF DYSART MAIN COAL

Frances Colliery, Dysart	Ft.	Ins.
Roof Coal	4	0
Stone	0	1
Spar Coal	1	8
Spar Stone	0	1
Head Coal	1	8
Clean Coal	1	6
Stone	0	4
Splint Coal	0	10
Stone	0	3
Nether Coal	3	6
Stone	0	1
Ground Coal	3	7
Stone	0	9
Thief Coal	5	0
	23	7

Balgonie Colliery	Ft.	Ins.
Spar Coal	1	3
Stone	0	3
Top Coal	3	3
Myslen Stone	0	9
Bottom Coal	3	9
	9	3

Wallsgreen Colliery, Buckhaven	Ft.	Ins.
Coal Roof	3	0
Top Coal	3	5
Myslen Stone	0	9
Bottom Coal	4	0
	11	2

In the working of such thick seams, especially when they are liable to spontaneous combustion, it is inevitable that a considerable proportion of the coal is lost. A description of the system of working adopted at Balgonie will be found in the *Transactions of the Mining Institute of Scotland*, vol. xii (1890).

From this description, and the discussion which followed, it would appear that although most of the Spar Coal (15 inches thick) is lost, that loss is considered inevitable under the circumstances. The attempt to win all the coal would probably lead to greater waste on account of spontaneous combustion.

As long ago as 1834 the workings of the Dysart Main Coal had extended for fully ¼ mile under the sea, as shown in Dr. Landale's paper in the *Transactions of the Highland Society*. Dr. Landale states that, as the seam gets farther under the sea, the nature of the coal changes entirely without meeting with trouble or dislocation of any kind. The splint gradually becomes of a bright metallic appearance in its fracture; it burns with much less flame, but intense heat, resembling coke, and is much used by brewers.

The Seven-foot Coal is the lowest workable seam of the series, although there are one or two thin seams underlying it. The section of the seams worked at the Sweet Dub pit, Gallatown, is given by the Geological Survey as below.

	Ft.	Ins.
Hard Gray Stone Roof		
Coal	1	3
Stone	0	1
Coal	2	4
Fireclay	2	6
Coal (Rough)	1	8
Coal (Parrot)	0	8
Coal (Rough)	0	8

Dr. Landale mentions that there was a band of argillaceous ironstone, about 2 feet thick, on the roof of the Seven-foot Coal, and that this ironstone had been wrought at Dysart by the Carron Company. At Balgonie, furnaces were erected for smelting the ironstone, but they were not very successful, although the quality of the ironstone was very good. The ironstone was also carried to the furnaces at Newcastle and at Carron.

THE KINGLASSIE COAL-FIELD.—The stratigraphical position of this coal-field is shown on the sections, figs. 1 and 2, Plate XIV. Eleven seams of coal have been proven, with a total thickness of nearly 60 feet. These seams occupy the same horizon as the Leven and Dysart seams, but it is not possible to establish an exact correlation between any of the individual seams. In the new edition of the Geological Survey map the boundaries of the Coal-measures in this district have been extended to include a good deal of what was marked on the old map as Millstone Grit. On the north the Coal-measures are cut off by the great boundary fault, which has been mentioned before as crossing the country from east to west. The other boundaries are thus described in the Geological Survey memoir. "These coals are disposed in a synclinal trough which is truncated on the north by the great fault. Its western lip begins about 500 yards to the west of the farm of Kinninmonth, whence it strikes from the fault-boundary in a south-westerly direction to near North Bogside, when it turns round under Boglochty and bends northward to the west side of Whinnyhall. There may possibly be another smaller basin of coal in the same field somewhere to the south of Kinglassie."

Of the eleven seams of coal in the Kinglassie section, only one or two which are of better quality have been worked, and these only to a limited extent. For various reasons the attempts which have been made to open up this field have not been very successful.

The latest attempt was by the Central Fife Coal Company, Limited, which was formed in 1894, but that company did not continue operations for many years.

The section of the Kinglassie seams, as found at Kinninmonth, is:—

	Fms.	Ft.	Ins.
No. 1 Coal	0	3	0
Strata	16	4	0
No. 2 Coal	0	5	5
Strata	28	2	0
No. 3 Coal	0	4	9
Strata	3	0	0
No. 4 Coal	0	5	0
Strata	3	0	0
No. 5 Coal	0	2	8
Strata	9	0	0
No. 6 Coal	0	4	4
Strata	20	0	0
No. 7 Coal	0	4	9
Strata	5	0	0
No. 8 Coal	0	3	9
Strata	2	3	0
No. 9 Blackband Ironstone	0	1	8
Coal	0	2	2
Strata	25	0	0
No. 10 Coal	0	4	4
Strata	15	0	0
No. 11 Coal	3	0	0

A comparison of this section with that of the Dysart and Leven district shows that there is no means of establishing detailed relationship between the various seams, but the

No. 11 Coal resembles the Dysart Main Coal, and the No. 2 Coal is supposed to correspond with the Leven Six-foot Coal.

A company has recently taken a lease of the Kinglassie Coal-field, with the intention of boring for the lower seams, as there does not appear to be much chance of opening up a profitable colliery in the Upper measures.

CHAPTER XIII

Undersea Coal

Along the Ayrshire coast, from Ayr to Ardrossan, the Carboniferous rocks dip below the Firth of Clyde, and the coal-seams which have been found inland must extend for some distance seaward. On the island of Arran, rocks containing thin seams of coal have been identified as of Lower Carboniferous age, and these, together with the fact that coal is also found on the Campbeltown coast, show that the Carboniferous formation originally extended for some distance westward from Ayrshire. Unfortunately the Coal-measures from Ayr northward by Troon and Irvine are so much invaded by intrusive igneous rocks that the coal along the coast is mostly unworkable, and there is thus very little inducement to search for it beyond the coast-line. Between Irvine and Ardrossan the conditions are rather more favourable, and the workings at present actually extend for about ¼ mile below high-water mark, and may in the future be extended much farther. Even allowing for this, the total quantity of coal which may probably be won from underneath the Firth of Clyde is comparatively insignificant, and there does not appear to be any important quantity of reserve coal in that direction.

Underneath the Firth of Forth the conditions are very different. There can be no doubt that the coal-fields of Fife and the Lothians extend right across beneath the firth, and that a very large quantity of coal is lying there under workable conditions. Reference has already been been made to the extension of workings seaward in the Coal-measures from the Fifeshire coast. On the southern side of the Firth coal-seams of the Carboniferous Limestone series are being worked for some distance beneath the sea at Prestongrange, and operations are now being carried on with the object of winning large areas of undersea coal both to the east and west of Prestongrange.

It will be observed that a trap dyke is shown on the map running about east and west along the coast at Cockenzie. The coals to seaward of this dyke have not yet been proven, but a shaft has been sunk near Cockenzie, and levels are now being driven forward to the dyke with the object of cutting it and proving the coal to seaward. The Forth Collieries, Limited, who are sinking this shaft, have leased from the Crown the coal for 2 miles beyond the coast-line, so that, if the coal-seams are found in workable condition beyond the trap dyke, a very large quantity of coals will be available. The dyke, as exposed on the coast, is only some 30 or 40 feet wide, and does not appear to occupy a line of fault, so that the operation of proving the coals appears to be quite simple, and may be completed ere this is published.

Some guidance as to the geological structure of the coal basin underneath the Firth may be obtained by tracing the anticline of the Pentland Hills northwards into Fifeshire. The axis of the anticline passes seaward at Leith, and is found emerging again near Burntisland. As before pointed out (p. 292), this anticline continues for some distance northward through the Kirkcaldy coal-field, and dies out in the vicinity of Markinch. The large fault which runs along the base of the Pentlands and forms the boundary of the coal-field disappears beneath the sea at Portobello, but does not appear to follow the line of the anticlinal axis, as there is no indication of it in the corresponding position on the Fifeshire coast. It is probable that it continues rather in a north-easterly direction, cutting across the coal basin at a flat angle, and joining with the faults which are found on the coast at Leven and Elie. If that theory is correct, the coal-basin is likely to be somewhat broken up where the line of faulting cuts across it. It has been observed that, passing northward from the Sheriffhall fault, the coal-field becomes much more disturbed and faulted, and it is very likely that as the coals are traced seaward this disturbance will become more pronounced.

The depth of water overlying the coal-beds is nowhere very great, about 100 feet being the maximum. The thickness of sand, &c., below the water is of course an unknown quantity. If it happens that these sands are underlain by an impervious bed of boulder-clay there is not much risk of water finding its way into the workings. Such a boulder-clay plays a very important part in the undersea workings opposite Bo'ness, but whether a similar covering exists between Fife and the Lothians is not yet known.

In Dr. Edward Hull's book on *Our Coal Resources*, the opinion is expressed that coal-mining under the Firth of Forth is impracticable on a large scale on account of the danger from water. The next few years will demonstrate how far Dr. Hull is correct in this assumption, but the capitalists who are now investing money for the development of undersea coal appear to entertain a more optimistic opinion.

In estimating as to the total quantity of coal which may be worked beneath the Firth of Forth, a fairly safe allowance would be 3 miles from each coast.

On this basis, and allowing for two-thirds of the coal remaining as barriers, &c., a total quantity of 1,000,000,000 tons will be available.

In the report of the Royal Commission on Coal an estimate of 1,800,000,000 tons is given as the amount of coal which may be recovered from underneath the Forth.

A proposal was made by the late Dr. David Landale to sink a shaft on the island of Inchkeith, in the middle of the Forth, where the estuary is about 7 miles wide, and win the coal by driving a long cross-cut to the east. The rocks of which Inchkeith is composed are mostly volcanic trap-beds in the horizon of the Calciferous Sandstone, so that to cross into the productive Coal-measures an immense extent of tunnelling would be necessary. In addition to this there would no doubt be difficulty on account of the inflow of water during sinking, as the rocks are dipping under the water at an angle of about 50°, and their outcrops are not protected by boulder-clay. As, however, Inchkeith is now the property of the War Office, and is bristling with fortifications, there is not much prospect of Dr. Landale's proposal being considered until the arrival of the millennium. Whether it might be possible to recover the coals beyond the 3-mile limit, by means of shafts sunk through the waters of the Forth, is a question which must receive serious consideration before our coal-fields are completely exhausted. The area of coal lying beyond the 3-mile limit in the Firth of Forth is about 61 square miles, and an average thickness of 50 feet throughout that area would contain over 900,000,000 tons of coal available for extraction after allowing for pillars and barriers.

CHAPTER XIV

Duration of the Coal-Fields

During the last few years there has been a growing feeling of uneasiness regarding the duration of our coal-supply, and this feeling has resulted in the appointment of a Royal Commission to make an exhaustive enquiry as to the extent of the coal resources of Great Britain. The alarm about the exhaustion of our coal-fields is no new thing, but has been of periodical recurrence during the last 400 years. Again and again efforts have been made to conserve the supply of coal by either prohibiting or restricting the export trade.

In 1563 the Scottish Parliament passed an act prohibiting all exportation of coal, except so much as was needful for fire during the time of the voyage. The penalty for breaking this law was confiscation of the ship and all its contents. The preamble of the act read as follows:—

"Our sovereign lady and estates foresaid, having consideration of the great multitude of coals continually carried forth of this realm, not only by strangers, but also by the lieges and inhabitants of the same, which is now becoming the common ballast of empty ships, and gives occasion of most exorbitant dearth and scantiness of fuel within the same."

It is to be noted how, even at this early period, ships arriving here with imports had a difficulty in getting a cargo to take back with them.

In spite of this act coal smuggling seems to have been continued, and in 1579 the act was strengthened by a provision to the effect that the revealer and apprehender of the contraveners of the said act were to receive one-third part of the confiscated property.

Even this did not seem sufficient to suppress what must evidently have been a lucrative trade. In 1585 another act was passed deploring this practice, which was attributed partly to the "iniquitie of the times" and partly to the negligence of the authorities, thus causing great dearth of coals and hurt to the commonwealth. The previous acts were therefore strengthened by making transporters and owners of the goods liable to fines, and punishment of their persons.

In 1597 the law against exportation of coal was again re-enacted, but in 1609 King James VI of Scotland was much troubled about the continued export of coal.

Certain of the lieges seem to have been specially licensed to export coal to recoup themselves for the great outlay which they had incurred in opening up their collieries and winning the coal. On 9th January, 1609, the king, writing to the privy council, referred to the acts of 1563 and 1579 prohibiting the export of coal, and ordered that "by open proclamation, upon the warrant of that statute, you prohibit and discharge all transporting of sea-coal whatsoever to any parts beyond the sea".

Some Fifeshire colliery owners protested against this interference with their trade, and petitioned the king to cancel the act. The king's reply was not mealy-mouthed, and is worth quoting.

"We cannot but marvel either at your great weakness in a matter concerning the public benefit, or then of your carelessness in preferring thereto the private lucre either of yourselves or friends. . . . It is a shameful thing that the private gain of some two or three persons should be put in balance, not only with the weal of that whole kingdom, but even of this whole isle, and I wonder how any doubt can be made of the vending of their coals, since coals are at this instant almost unbuyable for dearth."

How many of our modern business men would come under King James's castigation for preferring the private lucre of themselves and their friends before the public benefit! The ideals of public service must have been higher then than now, otherwise the king would hardly have ventured to speak in this manner. In spite, however, of King James's strong language those acts soon fell into disuse. In 1625 the Scotch Parliament passed a protective tariff act whereby a duty of forty-eight shillings (Scots) per ton was put upon all coal transported in foreign ships. The act says: "Neither will we any longer suffer that shameful abuse whereby, for the filthy gain of a few, the whole kingdom is wronged and strangers preferred to our national subjects".

This act also was the occasion of a protest by the Scottish coalmasters, in which they stated that the impost would divert the shipping from Scotch ports, and cause the stoppage of the collieries, "not only to the utter undoing of the owners, but also to the extreme hurt and prejudice of the country, and of hundreds of families of poor people, whose only maintenance depends upon their work, and without which they will all be turned beggars". Their protest seems to have met with a more favourable reception than the last one, as the act does not appear to have been enforced.

In 1644 there was an export duty of sixpence in the pound value of all coal exported in Scotch or English ships, and one shilling in the pound value of all coal exported in foreign ships. In 1696 the impost on coal carried in foreign ships was altered to eightpence per ton, and taxes of a similar nature remained in force until about forty-five years ago. The question of reviving the duty was considered by a select committee of the House of Commons, appointed in 1873 to enquire into the causes of the scarcity and dearness of coal. This committee reported very strongly against reimposing a duty, and even went so far as to say that there were special reasons against such an impost.

In order to form some judgment as to the future of our coal-supply, and whether it is necessary to restrict the exportation, I have compiled an estimate of the total quantity of coal which originally existed in each county and district. These quantities, of course, can only be approximately correct, but sufficient is now known about all the different coal-fields to enable us to make the calculations with a degree of accuracy which is probably sufficient for the purposes of this investigation. The detailed figures are given on Table I.[1] The quantities have been calculated on the basis that a seam of coal, 12 inches thick and 1 square mile in area, contains rather more than 900,000 tons. From this quantity, deductions require to be made for coal which is rendered unworkable by faults, wants, intrusive and interbedded igneous rocks, and other disturbances of the strata. An allowance has also to be made for loss in working, for barriers left round the boundaries of estates, and for coal left in to support buildings and other surface works. Taking account of all these circumstances it is not safe to allow for an actual recovery of more than 600,000 tons per square mile, 1 foot thick, and the quantities on Table I are estimated on this assumption. The quantities have also been divided into two classes, which for convenience are described as *proven* and *reserve.* Under the heading of *Proven Coal* are included all the known workable seams 2 feet thick and over. The *Reserve Coal* includes all the seams from 1 foot to 2 feet in thickness, and all the seams of that portion of the Carboniferous Limestone series which is covered by the Millstone Grit and the Coal-measures. In districts which have not been thoroughly explored by pits and bores a larger proportion of the coal has been put into the columns for reserve coal or "Thin and Uncertain Seams". These calculations were made about the year 1899, and were included in a paper read before the Mining Institute of Scotland. Since that date a considerable number of

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[1] *Transactions of the Inst. of Mining Engineers*, vol. xviii, p. 194.

TABLE I.—SHOWING THE TOTAL QUANTITY OF AVAILABLE COAL IN SCOTLAND.

NAME OF COUNTY AND DISTRICT.	UPPER COAL-MEASURES.						CARBONIFEROUS LIMESTONE.												TOTALS OF AVAILABLE COAL.	
							Surface-exposure.													
	Coal-seams being worked.			Thin and uncertain Coal-seams, &c.			Coal-seams being worked.			Thin and uncertain Coal-seams, &c.			Coal-seams lying below the Millstone Grit.			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Tons.	Tons.
AYRSHIRE—																				
Kilwinning	24·00	16	230,400,000	24·00	8	115,200,000	6.53	4	15,672,000	—	—	—	—	—	—	24·00	4	57,600,000	206,072,000	172,800,000
Kilmarnock	15·83	15	142,470,000	15·83	5	47,490,000	—	—	—	—	—	—	—	—	—	Probably unworkable			142,470,000	47,490,000
Galston	3·92	24	56,448,000	3·92	6	14,112,000	—	—	—	—	—	—	—	—	—	Do.		do. ..	56,448,000	14,112,000
Dundonald	—	—	—	10·34	3	18,612,000	—	—	—	—	—	—	—	—	—	Do.		do. ..	—	18,612,000
Adamhill	—	—	—	19·80	3	35,640,000	—	—	—	—	—	—	—	—	—	Do.		do. ..	—	35,640,000
Annbank	20·00	5	60,000,000	20·00	4	48,000,000	—	—	—	—	—	—	—	—	—	Do.		do. ..	60,000,000	48,000,000
Troon and Ayr	—	—	—	9·90	3	17,820,000	—	—	—	—	—	—	—	—	—	Do.		do. ..	—	17,820,000
Lugar and Cumnock ..	40·62	12	292,464,000	40·62	2	48,744,000	—	—	—	—	—	—	—	—	—	41·80	5	125,400,000	292,464,000	174,144,000
Sorn and Weitshaw ..	1·79	10	10,740,000	1·79	2	2,148,000	5·22	7	21,924,000	5·22	2	6,264,000	—	—	—	—	—	—	32,664,000	8,412,000
Muirkirk	—	—	—	—	—	—	5·80	25	87,000,000	5·80	5	17,400,000	3·26	20	39,120,000	—	—	—	87,000,000	56,520,000
Aird's Moss	—	—	—	—	—	—	—	—	—	—	—	—	1·75	20	21,000,000	—	—	—	—	21,000,000
New Cumnock	13·60	20	163,200,000	13·60	6	48,960,000	—	—	—	—	—	—	—	—	—	13·60	6	48,960,000	163,200,000	97,920,000
Guelt and Gasswater ..	—	—	—	—	—	—	—	—	—	1·75	12	12,600,000	—	—	—	—	—	—	—	12,600,000
Glaisnock	—	—	—	—	—	—	—	—	—	—	—	—	7·30	10	43,800,000	—	—	—	—	43,800,000
Dalmellington, North of	—	—	—	20·60	5	61,800,000	—	—	—	—	—	—	—	—	—	20·60	6	74,160,000	—	135,960,000
Dalmellington and Patna	13·49	25	202,350,000	13·49	8	64,752,000	1·89	10	11,340,000	1·89	1	1,134,000	5·64	10	33,810,000	13·49	6	48,564,000	213,690,000	148,260,000
Girvan	—	—	—	—	—	—	1·79	30	32,220,000	1·79	5	5,370,000	—	—	—	—	—	—	32,220,000	5,370,000
Dalry	—	—	—	—	—	—	12·12	4	29,088,000	—	—	—	—	—	—	—	—	—	29,088,000	—
Monkredding, &c. ..	—	—	—	—	—	—	—	—	—	6·81	2	8,172,000	—	—	—	—	—	—	—	8,172,000
DUMBARTONSHIRE—																				
Kirkintilloch	—	—	—	—	—	—	5·36	8	25,728,000	5·36	2	6,432,000	—	—	—	—	—	—	25,728,000	6,432,000
Nethercroy, &c.	—	—	—	—	—	—	8·71	4	20,904,000	8·71	2	10,452,000	—	—	—	—	—	—	20,904,000	10,452,000
Cumbernauld	—	—	—	—	—	—	—	—	—	8·69	3	15,642,000	6·66	3	11,988,000	—	—	—	—	27,630,000
Kilpatrick, &c.	—	—	—	—	—	—	6·40	1½	5,760,000	—	—	—	—	—	—	—	—	—	5,760,000	—
Garscube	—	—	—	—	—	—	3·50	6	12,600,000	3·50	2	4,200,000	—	—	—	—	—	—	12,600,000	4,200,000
LANARKSHIRE—																				
Clyde Basin, Upper Seams	62·30	20	747,600,000	62·30	2	74,760,000	—	—	—	—	—	—	—	—	—	62·30	2	74,760,000	747,600,000	149,520,000
Do., Lower Seams ..	62·30	5	186,900,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	186,900,000	—
Millerston to Airdrie ..	18·50	8	88,800,000	18·50	2	22,200,000	—	—	—	—	—	—	—	—	—	18·50	1	11,100,000	88,800,000	33,300,000
New Monkland	20·50	9	110,700,000	20·50	2	24,600,000	—	—	—	—	—	—	—	—	—	20·50	3	36,900,000	110,700,000	61,500,000
Chapelhall and Harthill	51·08	12	367,776,000	51·08	3	91,944,000	—	—	—	—	—	—	—	—	—	51·08	6	183,888,000	367,776,000	275,832,000
Newmains	9·10	14	76,440,000	9·10	1	5,460,000	—	—	—	—	—	—	—	—	—	9·10	8	43,680,000	76,440,000	49,140,000
Wilsontown	—	—	—	—	—	—	8·90	10	53,400,000	—	—	—	15·06	8	72,288,000	—	—	—	53,400,000	72,288,000
Carluke	—	—	—	—	—	—	3·82	8	18,336,000	3·82	2	4,584,000	—	—	—	—	—	—	18,336,000	4,584,000
Auchenheath	—	—	—	—	—	—	5·30	2	6,360,000	—	—	—	—	—	—	—	—	—	6,360,000	—
Avondale	12·80	4	34,560,000	12·80	3	23,040,000	—	—	—	—	—	—	—	—	—	12·80		probably unworkable	34,560,000	23,040,000
East Kilbride and Quarter	—	—	—	—	—	—	—	—	—	35·26	2	42,336,000	—	—	—	—	—	—	—	42,336,000

TABLE I.—*Continued.*

NAME OF COUNTY AND DISTRICT.	UPPER COAL-MEASURES.						CARBONIFEROUS LIMESTONE.												TOTALS OF AVAILABLE COAL.	
							Surface-exposure.													
	Coal-seams being worked.			Thin and uncertain Coal-seams, &c.			Coal-seams being worked.			Thin and uncertain Coal-seams, &c.			Coal-seams lying below the Millstone Grit.			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
LANARKSHIRE—*Cont.*	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Tons.	Tons.
Garnkirk	—	—	—	—	—	—	—	—	—	—	—	—	19·93	4	47,832,000	—	—	—	—	47,832,000
Cadder	—	—	—	—	—	—	8·40	3	15,120,000	8·40	3	15,120,000	—	—	—	—	—	—	15,120,000	15,120,000
Glasgow	—	—	—	—	—	—	13·21	5	39,630,000	—	—	—	6·68	4	16,032,000	—	—	—	39,630,000	16,032,000
Douglas	2·40	20	28,800,000	2·40	8	11,520,000	—	—	—	—	—	—	—	—	—	2·40	10	14,400,000	28,800,000	25,920,000
Coalburn	—	—	—	—	—	—	4·30	20	51,600,000	4·30	5	12,900,000	—	—	—	—	—	—	51,600,000	12,900,000
Rigside	—	—	—	—	—	—	1·50	40	36,000,000	1·50	10	9,000,000	—	—	—	—	—	—	36,000,000	9,000,000
Brokencross Muir ..	—	—	—	—	—	—	3·20	6	11,520,900	3.20	4	7,680,000	—	—	—	—	—	—	11,520,000	7,680,000
Glespin	1·80	25	27,000,000	1·80	10	10,800,000	—	—	—	2·00	10	12,000,000	—	—	—	2·75	10	16,500,000	27,000,000	39,300,000
RENFREWSHIRE—																				
Paisley	—	—	—	—	—	—	—	—	—	14·00	3	25,200,000	—	—	—	—	—	—	—	25,200,000
Linwood	—	—	—	—	—	—	6·28	6	22,608,000	10·08	3	18,144,000	—	—	—	—	—	—	22,608,000	18,144,000
Renfrew	—	—	—	—	—	—	—	—	—	3·36	6	12,096,000	—	—	—	—	—	—	—	12,096,000
Quarrelton	—	—	—	—	—	—	0·25	92	13,800,000	—	—	—	—	—	—	—	—	—	13,800,000	—
Howwood	—	—	—	—	—	—	0·86	3	1,548,000	0·86	2	1,032,000	—	—	—	—	—	—	1,548,000	1,032,000
Pollok, &c.	—	—	—	—	—	—	12·80	5	38,400,000	12·80	3	23,040,000	1·39	8	6,672,000	—	—	—	38,400,000	30,712,000
Lochwinnoch	—	—	—	—	—	—	2·80	4	6,720,000	—	—	—	—	—	—	—	—	—	6,720,000	—
Caldwell	—	—	—	—	—	—	0·40	4	960,000	—	—	—	—	—	—	—	—	—	960,000	—
STIRLINGSHIRE—																				
Kilsyth	—	—	—	—	—	—	7·14	8	34,272,000	7·14	2	8,568,000	—	—	—	—	—	—	34,272,000	8,568,000
Denny	1·80	11	11,880,000	1·80	2	2,160,000	—	—	—	3·46	3	6,228,000	—	—	—	—	—	—	11,880,000	8,388,000
Bannockburn, &c. ..	—	—	—	—	—	—	15·84	6	57,024,000	15·84	3	28,512,000	—	—	—	—	—	—	57,024,000	28,512,000
Carron	12·50	6	45,000,000	12·50	3	22,500,000	—	—	—	—	—	—	—	—	—	12·50	3	22,500,000	45,000,000	45,000,000
Dunmore	4·84	4	11,616,000	4·84	2	5,808,000	—	—	—	—	—	—	8·91	7	37,422,000	4·84	3	8,712,000	11,616,000	51,942,000
Falkirk	5·15	8	24,720,000	5·15	3	9,270,000	—	—	—	—	—	—	1·32	5	3,960,000	15·73	5	47,190,000	24,720,000	54,420,000
Slamannan, &c.	31·96	3¾	71,910,000	31·96	1	19,176,000	—	—	—	—	—	—	—	—	—	34·17	5	102,510,000	71,910,000	66,366,000
Larbert	—	—	—	—	—	—	—	—	—	—	—	—	15·13	5	45,390,000	—	—	—	—	45,390,000
Polmont	—	—	—	—	—	—	—	—	—	—	—	—	3·44	7	14,448,000	—	—	—	—	14,448,000
Lennoxtown	—	—	—	—	—	—	—	—	—	12·00	2	14,400,000	—	—	—	—	—	—	—	14,400,000
Kinneil Kerse	—	—	—	—	—	—	—	—	—	2·19	4	5,256,000	2·11	5	6,330,000	—	—	—	—	11,586,000
CLACKMANNANSHIRE—																				
Alloa	13·19	10½	83,097,000	13·19	3½	23,742,000	—	—	—	0·98	Unknown		9·47	10	56,820,000	19·83	6	71,388,000	83,097,000	151,950,000
FIFE AND KINROSS—																				
Pittenweem and Elie ..	—	—	—	—	—	—	—	—	—	1·00	30	18,000,000	—	—	—	—	—	—	—	18,000,000
Dysart	13·19	25	197,850,000	13·19	4	31,656,000	—	—	—	—	—	—	—	—	—	16·55	20	198,600,000	197,850,000	230,256,000
Wemyss	5·40	35	113,400,000	5·40	20	64,800,000	—	—	—	—	—	—	6·50	20	78,000,000	5·40	20	64,800,000	113,400,000	207,600,000
Carriston	—	—	—	—	—	—	6·79	8	32,592,000	6·79	4	16,296,000	—	—	—	—	—	—	32,592,000	16,296,000
Clatto	—	—	—	—	—	—	—	—	—	0·58	2	696,000	—	—	—	—	—	—	—	696,000

TABLE I.—*Continued.*

NAME OF COUNTY AND DISTRICT.	UPPER COAL-MEASURES.						CARBONIFEROUS LIMESTONE.												TOTALS OF AVAILABLE COAL.	
	Coal-seams being worked.			Thin and uncertain Coal-seams, &c.			Surface-exposure. Coal-seams being worked.			Surface-exposure. Thin and uncertain Coal-seams, &c.			Coal-seams lying below the Millstone Grit.			Coal-seams lying below the Upper Coal-measures.				
	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Area.	Thickness.	Quantity of Coal.	Proven.	Reserves.
	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. Miles	Ft.	Tons.	Sq. miles.	Ft.	Tons.	Tons.	Tons.
FIFE AND KINROSS—*Cont.*																				
Kilmux	—	—	—	—	—	—	4·01	15	36,090,000	4·01	10	24,060,000	—	—	—	—	—	—	36,090,000	24,060,000
Teasses	—	—	—	—	—	—	8·12	5	24,360,000	8·12	5	24,360,000	—	—	—	—	—	—	24,360,000	24,360,000
Ceres	—	—	—	—	—	—	0·86	20	10,320,000	0·86	20	10,320,000	—	—	—	—	—	—	10,320,000	10,320,000
Lathallan	—	—	—	—	—	—	6·84	8	32,832,000	6·84	2	8,208,000	—	—	—	—	—	—	32,832,000	8,208,000
Lochty	—	—	—	—	—	—	18·70	6	67,320,000	18·70	4	44,880,000	—	—	—	—	—	—	67,320,000	44,880,000
Drumcarrow	—	—	—	—	—	—	—	—	—	1·20	2	1,440,000	—	—	—	—	—	—	—	1,440,000
Kirkcaldy	—	—	—	—	—	—	8·40	20	100,800,000	8·40	6	30,240,000	—	—	—	—	—	—	100,800,000	30,240,000
Kinglassie	2·20	14	18,480,000	2·20	3	3,960,000	—	—	—	—	—	—	—	—	—	3	20	36,000,000	18,480,000	39,960,000
Capledrae	—	—	—	—	—	—	2·03	2	2,436,000	2·03	12	14,616,000	—	—	—	—	—	—	2,436,000	14,616,000
Lochgelly and Bowhill ..	—	—	—	—	—	—	10·75	30	193,500,000	10·75	14	90,300,000	—	—	—	—	—	—	193,500,000	90,300,000
Blairadam and Kelty ..	—	—	—	—	—	—	12·74	20	152,880,000	12·74	7	53,508,000	—	—	—	—	—	—	152,880,000	53,508,000
Dunfermline and Cowdenbeath	—	—	—	—	—	—	8·80	35	184,800,000	8·80	10	52,800,000	—	—	—	—	—	—	184,800,000	52,800,000
West of Fife	—	—	—	—	—	—	18·59	5	55,770,000	18·59	10	111,540,000	3·21	10	19,260,000	—	—	—	55,770,000	130,800,000
Dollar and Blairingone ..	1·19	6	4,284,000	—	—	—	—	—	—	—	—	—	—	—	—	1·19	6	4,284,000	4,284,000	4,284,000
EDINBURGHSHIRE—																				
*Niddrie and Millerhill ..	9·10	30	163,800,000	9·10	10	54,600,000	1·04	40	35,193,600	1·04	20	17,596,800	0·35	60	10,500,000	9·10	60	327,600,000	198,993,600	410,296,800
Inveresk	—	—	—	—	—	—	1·12	20	13,440,000	1·12	5	3,360,000	2·01	25	30,150,000	—	—	—	13,440,000	33,510,000
*Loanhead, &c.	9·80	15	88,200,000	9·80	2	11,760,000	2·60	55	120,978,000	2·60	25	54,990,000	7·00	40	193,200,000	9·80	40	235,200,000	209,178,000	495,150,000
*Penicuik	—	—	—	—	—	—	5·40	10	32,400,000	5·40	5	16,200,000	—	—	—	—	—	—	32,400,000	16,200,000
Newbattle	—	—	—	—	—	—	6·87	40	181,368,000	6·87	6	27,206,200	—	—	—	—	—	—	181,368,000	27,206,200
Vogrie and Pathhead ..	—	—	—	—	—	—	4·85	6	17,460,000	4·85	2	5,820,000	—	—	—	—	—	—	17,460,000	5,820,000
Temple	—	—	—	—	—	—	9·30	4	22,320,000	9·30	2	11,160,000	—	—	—	—	—	—	22,320,000	11,160,000
Brunstane	—	—	—	—	—	—	9·10	4	21,840,000	9·10	2	10,420,000	3·96	4	9,360,000	—	—	—	21,840,000	19,780,000
West Calder	—	—	—	—	—	—	4·60	2	5,520,000	—	—	—	—	—	—	—	—	—	5,520,000	—
HADDINGTONSHIRE—																				
Tranent	—	—	—	—	—	—	4·54	15	40,860,000	4·54	5	13,620,000	—	—	—	—	—	—	40,860,000	13,620,000
Cousland, &c.	—	—	—	—	—	—	—	—	—	4·17	10	25,000,000	—	—	—	—	—	—	—	25,000,000
Ormiston	—	—	—	—	—	—	13·76	10	82,560,000	13·76	2	16,512,000	—	—	—	—	—	—	82,560,000	16,512,000
Prestongrange	—	—	—	—	—	—	0·68	30	12,240,000	0·68	7	2,856,000	—	—	—	—	—	—	12,240,000	2,856,000
LINLITHGOWSHIRE—																				
Westcraigs and Armadale	17·83	7½	80,235,000	17·83	1	10,698,000	—	—	—	—	—	—	2·60	6	9,360,000	17·83	6	64,188,000	80,235,000	84,246,000
Benhar	5·90	12	42,480,000	5·90	5	17,700,000	—	—	—	—	—	—	5·76	10	34,560,000	5·90	6	21,240,000	42,480,000	73,500,000
Crofthead	—	—	—	—	—	—	1·60	10	9,600,000	6·07	2	7,284,000	—	—	—	—	—	—	9,600,000	7,284,000
Bathgate	—	—	—	—	—	—	3·23	6	11,628,000	3·23	2	3,876,000	—	—	—	—	—	—	11,628,000	3,876,000
West Calder to Champfleurie	—	—	—	—	—	—	12·75	2	15,300,000	—	—	—	—	—	—	—	—	—	15,300,000	—
Linlithgow and Bo'ness	—	—	—	—	—	—	10·70	8	51,360,000	10·70	4	25,680,000	1·00	5	3,000,000	—	—	—	51,360,000	28,680,000

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* In estimating those quantities an allowance has been made for the inclination of the strata.

deep bores have been put down, which have been referred to in the preceding chapters. In some cases these bores have shown less coal than estimated, but in the majority of cases they have shown that the estimates are rather under the truth than over it.

It is as well, however, to let the figures remain as they are, as any alteration which might be made is not of sufficient magnitude to have much effect on the general result. Having thus estimated the total quantity of available coal, it is necessary to arrive at some conclusion as to the quantity of coal which has already been worked out. There are no exact figures to show the annual output of coal prior to 1854. The Royal Commission on Coal, after investigating all the available records, gave the following estimates of the output of the United Kingdom for various years since 1660:—

Table II.—Output of Coal in United Kingdom

1660	2,148,000
1700	2,612,000
1750	4,773,828
1770	6,205,400
1780	6,424,976
1790	7,618,760
1800	10,080,300
1816	16,000,000 to 27,000,000

By plotting these figures on a diagram and continuing the curve backwards, the output for each year can be estimated with a fair degree of accuracy. From 1854 onwards, statistics have been published by the Home Office showing the actual output of the country from returns made by the mine-owners. The figures are given in Appendix II, and have been plotted on the diagram, fig. 9.

From 1854 to the present date the output of Scotland has represented on an average 13.3 per cent of the output of the United Kingdom, and it may be assumed that in previous years the proportion would be about the same. Taking the actual output of Scotland from the year 1854 onward, and estimating the output prior to that date on the above hypothesis, it is found that the total quantity of coal which has been worked in Scotland up to the present date amounts to 1,540,000,000 tons.

In order to allocate the proportion of this output to each of the counties a somewhat similar method has been adopted. Since 1876 returns have been published showing separately the output from each county (see Appendix I), and from these returns it is estimated that from 1876 to the present date each county's contribution to the total output has been as shown in the following table:—

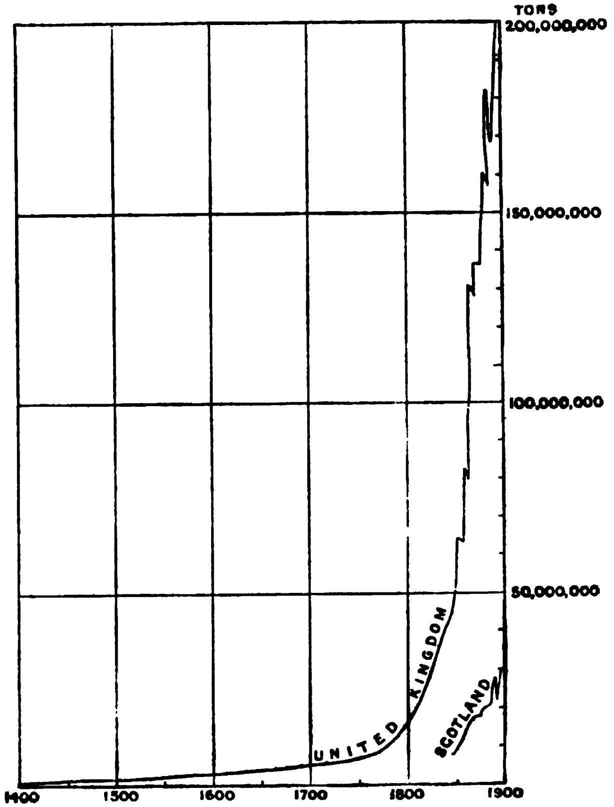

Fig. 9.—Diagram showing the Output of Coal from the United Kingdom since 1400, and the Output of Coal from Scotland since 1854

TABLE III.—SHOWING PROPORTION OF TOTAL OUTPUT WROUGHT FROM EACH COUNTY

Counties.	Per Cent.
Argyll, Dumfries, &c.	0.85
Ayr	14.35
Dumbarton	1.40
Lanark	55.90
Renfrew	0.35
Stirling	6.05
Clackmannan	1.40
Edinburgh	3.75
Fife and Kinross	11.95
Haddington	1.20
Linlithgow	2.80

The total coal worked from each county has been estimated by allocating a total of 1,504,000,000 tons in proportion to the above percentage, and these figures are detailed in Table IV.

TABLE IV.—SHOWING TOTAL QUANTITY OF AVAILABLE COAL

County.	Total Available Quantity of Proven Coal	Quantity Worked.	Total Quantity still to Work.	Estimated Quantity of Unproven Coal in Reserve.
	Tons.	Tons.	Tons.	Tons.
Argyll, Dumfries, Perth, & Sutherland	117,788,000	12,788,000	105,000,000	166,843,120
Ayr	1,355,316,000	215,824,000	1,139,592,000	1,066,652,000
Dumbarton ...	64,992,000	21,056,000	43,936,000	48,714,000
Lanark	1,900,542,000	840,736,000	1,059,806,000	885,324,000
Renfrew	84,036,000	5,264,000	78,772,000	87,184,000
Stirling	256,422,000	90,992,000	165,430,000	349,020,000
Clackmannan ...	83,097,000	21,056,000	62,041,000	151,950,000
Edinburgh ...	702,519,600	56,400,000	646,119,600	1,019,122,000
Fife and Kinross	1,227,714,000	179,728,000	1,047,986,000	966,624,000
Haddington ...	135,660,000	18,048,000	117,612,000	57,988,000
Linlithgow ...	210,003,000	42,112,000	168,491,000	197,586,000
Firth of Forth ...	—	—	—	1,000,000,000

The net result of these calculations shows that the following quantity of coal is still available:—

	Tons.
Proven coal at moderate depths	4,634,785,600
Thin seams and deep seams	5,994,327,120
Total	10,629,112,720

The question as to how long this coal will last is not one that admits of a very definite answer. The output of coal since 1600 has been steadily progressive, and the problem is, how long will this progress continue? The continued increase of the output is intimately associated with the industrial prosperity of the country, and the increased prosperity is reflected in the increase of population.

On the following table statistics are given showing the relation between the output, the exportation of coal, and the home consumption in Scotland for each decade since 1861:—

Year.	Output of Coal.	Export of Coal.	Proportion Remaining for Home Consumpt.	Consumption of Coal per head of Population.
	Tons.	Tons.	Tons.	Tons.
1861	11,081,100	709,000	10,372,100	—
1871	15,438,291	1,419,681	14,018,610	4.172
1881	20,823,055	2,242,866	18,580,189	4.974
1891	25,323,818	4,501,493	20,822,325	5.172
1900[1]	33,112,104	7,376,942	25,735,162	5.813

An examination of these figures shows that there has been a steady increase in the proportion of the output exported. In 1861 the proportion exported was only 6.4 per cent of the output, whereas it now amounts to 20 per cent of the output.

It is remarkable that the home consumption per head of the population is much higher in Scotland than in the whole kingdom. The home consumption of coal in the United Kingdom amounted in the year 1891 to 3.846 tons per head of population, whereas in Scotland it amounted to 5.172 tons per head of population. Whether this is due to the bad climate or to the greater industry of the people is a matter of debate.

While the estimates of home consumption of coal given by the Royal Commission have so far proved in the main correct, their forecast regarding the exportation of coal has been very much falsified. After having made a careful examination of the coal resources of foreign countries with the view of ascertaining what likelihood there was of our country being able to hold its own in the coal-markets of the world, they came to the conclusion that the outputs of several foreign countries would soon be sufficient for all the requirements of these countries, and that there was therefore not much prospect of any material increase in our annual coal export. At the date when this forecast was made the coal export of Great Britain amounted to 12,000,000 tons per annum, equal to about 16 per cent of the whole output. At the present date (1901) our coal exports (including coal used in ships engaged in the foreign trade) amount to 55,465,178 tons.

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[1] The figures for 1901 were not available at the time of writing.

This is fully four and one-half times as much as the exports were in 1871, when the Royal Commission considered that a maximum had been reached. The increase in the quantity of coals exported is very much out of proportion to the increase in the output. In 1871 the exports amounted to 16 per cent of the home consumption, whereas now the exports are over 25 per cent of the home consumption.

Table V contains an estimate of the future output of Scotland. Column 1 gives the estimated home consumption of the United Kingdom, taken from the report of the Royal Commissioners on Coal. The output of coal in Scotland during the last ten years has been on an average equal to 15.2 per cent of the output of the United Kingdom. Therefore, in column 2 the estimated home consumption of Scotland has been taken at 15.2 per cent of the consumption of the United Kingdom. The export of coal from Scotland is taken at 25 per cent of the home consumption, and in this way the third column of the table has been calculated. On the basis of this estimate, all the proven coal in Scotland will be exhausted by the year 1994, and all the reserve coal will be exhausted by the year 2086.

It is of course evident that long before these dates are

TABLE V.—SHOWING ESTIMATED OUTPUT OF COAL IN SCOTLAND BASED ON THE ESTIMATE OF CONSUMPTION OF COAL IN THE UNITED KINGDOM AS MADE BY THE ROYAL COMMISSION ON COAL IN 1871.

Year.	United Kingdom.	Scotland.	
	1. Estimated Consumption.	2. Estimated Consumption on the Basis of 15.2 per cent of the Consumption of the United Kingdom.	3. Exports on the Basis of 25 per cent of the Consumption of Scotland.
	Tons.	Tons.	Tons.
1901	162,400,000	24,684,800	6,171,200
1911	178,000,000	27,056,000	6,764,000
1921	193,200,000	29,366,400	7,341,600
1931	208,700,000	31,722,400	7,930,600
1941	224,800,000	34,169,600	8,542,400
1951	241,100,000	36,647,200	9,161,800
1961	257,600,000	39,155,200	9,788,800
1971	274,200,000	41,678,400	10,419,600
1981	290,800,000	44,201,600	11,050,400
1991	307,400,000	46,724,800	11,681,200
2001	323,900,000	49,232,800	12,308,200
2011	340,300,000	51,725,600	12,931,400
2021	355,700,000	54,066,400	13,766,600
2031	371,700,000	56,498,400	14,124,600
2041	387,400,000	58,884,800	14,721,200
2051	402,800,000	61,225,600	15,306,400
2061	417,900,000	63,520,800	15,880,200
2071	432,700,000	65,770,400	16,442,600
2081	447,000,000	67,944,000	16,986,000
2091	461,000,000	70,072,000	17,518,000

reached the continued increase of the output will have received a check, and that just as the output has gradually increased, so also will it gradually diminish. The vital consideration is that within a comparatively short time the mines of Scotland will be unable to supply the necessary coal for the continuance of that increase of the trade and population of the country which has been so marked a feature of the last century. Assuming that the annual increment continues until 1941, when the Scottish output will have reached a total of 40,000,000 tons per annum, there will be sufficient coal left to maintain the output at that rate until the year 2160; but even on this assumption cheaply-worked coal will only last until about the end of the present century.

ther it will be possible to continue increasing the very much beyond its present figure depends, of on the total quantity which it is possible to produce ne coal area in any one year. There is no doubt ractically all the coal areas in Scotland are being l more or less vigorously; but notwithstanding this, tput can be, and doubtless will be, very considerably sed. The Lanarkshire coal-field supplies a striking ation of the possibilities of a large output from a aratively small area.

e total coal-bearing area of Scotland is about 1200 e miles, and the coal area of Lanarkshire is about quare miles, equal to one-fourth of the whole. Yet anarkshire area is producing 56 per cent of the whole t of Scotland.

the other districts were producing coal at the same in proportion to their areas, then the whole output of Scotland would amount to over 60,000,000 tons per annum.

So far, therefore, as capacity of production is concerned, there is no reason why an output amounting to 60,000,000 tons per annum should not be obtained.

Dealing with the same problem in relation not to the area, but to the total quantity of proven coal in each county, a similar result can be arrived at.

TABLE VI

County.	Proportion of Average Annual Output.	Unwrought Proven Coal.
	Per cent.	Per cent.
Lanark	55.90	22.8
Ayr	14.35	24.6
Fife	11.95	22.6
Stirling	6.05	3.6
Edinburgh	3.75	13.9
Linlithgow	2.80	3.6
Others	5.20	8.9

In Table VI column 1 shows the proportion of the average annual output which comes from each county, and column 2 shows the proportion of the 4,634,785,600 tons of proven coal still to work in each of the counties. If each county were producing coal in proportion to its capacity, as indicated by column 2, the distribution of the output would be very different from what it is at the present moment.

If the county of Lanarkshire is to continue its present rate of production and increase, the whole of the proven coal in that county will be exhausted in about forty to fifty years. The principal part of the Lanarkshire output comes at present from the great industrial centre of the Clyde basin. There is little doubt that within twelve or fifteen years the thick and easily-wrought seams of that basin will be approaching exhaustion, and it will not then be possible for Lanarkshire to continue producing such a large proportion of the Scottish output.

At first sight this fact seems to be a very serious one for Glasgow and the surrounding districts. There can be no doubt that the rapid growth of the great manufacturing industries of the West of Scotland was fostered by the opening up of the Clyde valley coal-field thirty to forty years ago, whereby an abundant and cheap supply of coals was obtained.

Originally the manufacturers had an undoubted advantage from their proximity to the coal-mines, but as mineral leases have expired and new collieries have been opened up, the circumstances have been entirely reversed. It is now the mines which have the advantage, from their proximity to the manufacturers.

This advantage goes to the mineral land-owner in the form of increased rents and royalties, or, in cases where the collieries are being worked under old leases, it goes to the colliery owners in the shape of enhanced profits.

It thus happens that the royalties paid for coal in the Clyde valley are generally from *4d.* to *1s.* per ton higher than the lordships payable for similar coal in the outlying districts. It is very questionable if the cost of fuel will be materially increased even when the Clyde valley coal-field is exhausted. As these coals become more scarce, a higher rate of railway carriage will require to be paid to bring coals from a greater distance; but there is no reason to assume that the whole of this burden will fall on the consumer. The principal difference will be that less money will be paid to the land-owners, and more will be paid to the railway companies. At the same time the thinner seams of the Lanarkshire coal-field will be opened up at reduced royalties.

Although it may not be possible to maintain such a large output from these thinner seams, the Lanarkshire output, although it does not increase at the same rate as it has done in the past, is not likely to decrease to any serious extent for a very long time. There is still a very large quantity of coal underlying the Coal-measures, which has never yet been tapped.

From the figures already given, it will be seen that the total of the proven and reserve coal in Lanarkshire amounts to 1,944,000,000 tons. Even allowing for an output of 20,000,000 tons per annum, that quantity of coal will last for nearly 100 years.

If an increased output is not to be obtained from Lanarkshire, then the other counties will require to increase their output at a greater proportionate rate if the whole output of Scotland is to continue increasing as it has done in the past.

Since 1878 the county of Fifeshire has increased its output threefold, but recent developments lead to the conclusion that the maximum output of that county is not yet even in sight.

It is remarkable what a number of deep bores have been put down in that county within the last two or three years, and several more very deep bores are in contemplation.

It may be assumed that coalmasters are not putting down these deep and expensive bores purely for curiosity, but that they mean to follow them up by sinking shafts and working the coal.

It is therefore safe to say that we are on the eve of great developments in that county in the way of deep sinkings and large outputs.

The county of Edinburgh has been somewhat stagnant, so far as increase of coal output is concerned, during the last thirty years, and this is the more remarkable when it is remembered that that county was at one time considered very progressive, and it was there that some of the earliest coal-workings on record took place.

When it is stated that the quantity of coal in Edinburghshire is sufficient to maintain the present output for more than 1000 years, it is evident that there is room for an enormous increase of output. On the western side of the basin, where the seams are lying at a high angle, there is certainly a physical difficulty in getting a very large output, but in the centre of the basin and on the eastern side the seams are either lying flat or at very moderate inclinations. That portion of the field between Dalkeith and the shores of the Forth has remained very much undeveloped in the past, partly on account of the very conservative policy adopted by certain land-owners. Fortunately this policy has now been reversed, and at the present moment important developments are in progress, whereby the output of the county should soon be doubled or trebled. Farther south the great sinking at the Newbattle Colliery has now been completed, and the underground workings are being opened up so as to produce a great increase of the output. At Penicuik, also, the coal-workings, which have been abandoned for several years, are again being opened out.

Under these circumstances it is possible to take a somewhat optimistic view of the future of the coal production in the county of Edinburgh, and to predict that before many years have elapsed it will occupy a very important position in the coal trade of Scotland.

The only other district from which a notable increase of output might be expected is the county of Ayr. It is a remarkable fact that there is more coal still to work in that

than there is in the whole of Lanarkshire, and yet
re only produces an output equal to less than one-
of the Lanarkshire output. A reference to the
tics in Appendix I shows that during the last ten
Ayrshire has made remarkably little progress. Of
e many of the Ayrshire coal-fields are somewhat
ed from the best markets, and are not properly
ed up with railway connections. The working of the
is also interfered with to some extent by intrusive
us rocks, but not to a greater extent than in Fifeshire.
eems inevitable that in the course of the next few
des Glasgow and the West of Scotland will require to
much more extensively on Ayrshire for their coal-
lies, and as this demand begins to make itself felt, it
doubtless cause a more vigorous development of the
fields and the adoption of a more liberal railway
y.

The output from the county of Renfrew has shown a steady decline during the last twenty years. In 1878 that county was producing over 163,000 tons per annum, but last year the whole output was only 12,491 tons.

The best of the Renfrewshire coals, viz., those in the near vicinity of Glasgow, are now exhausted. There is still a good deal of coal to work in inferior seams, such as the Hurlet coal, but it is not likely that these seams will be opened up to any great extent in the meantime.

The county of Clackmannan is also showing some decline in its coal output. There is, however, a fair prospect of a considerable increase in the output of that county if the deep boring at present being conducted on Tullyallan estate proves the lower measures to contain sufficient workable coal-seams to justify the deep sinkings which will be necessary for their exploitation.

In considering the future of the coal trade of this country one of the most important points is the exportation of coal. It has already been shown how often attempts have been made to restrict this export trade, and yet in spite of these attempts the exportation has continued steadily to increase. It is evident that the whole prosperity of the country is intimately bound up with the exportation of coal, and a stoppage of that exportation would be a deadly blow, not to the coal trade only, but to the whole industry of the country. If we cease to export our coals we will require to deport our children, otherwise it will be impossible to find occupation for a population which is increasing as that of Great Britain has been doing during the last century. For instance, we are dependent on imports from foreign countries for most of our food-supply. As coal is the only heavy article available for export in return, there is obviously a very intimate relation between the exportation of coal and the cheap supply of food-stuffs to this country.

If outward-bound vessels are unable to obtain an export cargo it will result in a heavy increased cost of freight on imports, and this increased cost will quickly reflect on the general trade of the country.

As an example, we have been importing annually from the Argentine Republic about 400,000 tons of grain and over 800,000 head of cattle, sheep, &c., and against this we have exported about 1,000,000 tons of coal, so that the ships bringing our food-stuffs from that country have had a return cargo about equivalent to the imports.

The principal argument which can be advanced in favour of any policy that would have the effect of curtailing the exportation of coal is the supposed necessity of securing to posterity a supply of coal sufficient for their probable requirements.

As matters stand, we are pretty sure of a supply of coals which will last us for, say, 150 years, maintaining the present ratio of increase and exports. If, therefore, we impose a tax on ourselves just now, it will be for the benefit of those who are inhabiting these islands in the latter half of the twenty-first century.

Our export of coal amounted last year (1899) to

41,180,300 tons, for which the foreigner pays us over £25,000,000.

Suppose we pass a self-denying ordinance and leave the coal unworked for one year, we would thus lose £25,000,000. If, however, instead of leaving the coal to our descendants, we take the £25,000,000 and invest it for them at 2½ per cent simple interest, it would accumulate to £118,000,000 in the 150 years. Surely posterity will thank us more if we leave them a purchasing power represented by £118,000,000 than if we leave them the 41,000,000 tons of coal.

Does there not seem to be a considerable parallel between those who propose to leave our coals buried in the earth and the man who allowed his talent to lie wrapped up in a napkin?

We have also to consider the amount of capital invested and the number of men employed transporting the coal from pit to port. If the railway companies are deprived of this source of revenue, they must increase rates on other traffic, and so also must the dock and harbour companies.

Another argument frequently heard in favour of limiting the exportation of coal, is that we are supplying coal to our competitors, and that if we stopped their supplies it would give a great impetus to our home industries, especially to the iron trade. It should be noted that this argument is brought forward under the cloak of the scare about our coal being exhausted, but that is really only a secondary consideration.

For instance, we supply Germany with about 5,000,000 tons of coal per annum, and it is by the use of this coal that that country is enabled to compete so closely with us, especially in the various forms of iron work. It would certainly have a grave effect on the iron industry of Germany if we could increase the cost of their coal-supplies, and it would relieve our manufactures from an inconvenient opposition. If we could confine the prohibition against export of coal to those countries which, like Germany, are using our fuel to oust us from our trade with the world, it would appear to be so much the better for us.

This benefit, however, is only apparent, for although such a disturbance of our fiscal laws might be a very good thing for one particular class of the community, it would, in essence, simply mean a return to protection in a most pernicious form, and it is not likely that this country will now tolerate any tampering with the principles of free-trade.

The coal resources of the country might also be conserved by the exercise of greater care to prevent unnecessary loss in working. In very many cases it is more profitable for the coal-owner to work out quickly the best seams in a coal-field, even if such working results in an ultimate loss of coal in some of the inferior seams. In past times the amount of coal that has been wasted in this way is very great, and the absence of exact records of these old workings is still a cause of loss on account of barriers which have to be left to protect the present workings. Even yet our hands are not quite clean in that respect.

Take, for example, the Lanarkshire Ell Coal, which is frequently found 9 feet in thickness. The Upper Three-foot is of second-class quality, and throughout thousands of acres it has been found more profitable to work only the Lower Six-foot, and the remainder is left in the workings and absolutely lost. Instances of a similar kind could be given in all parts of the country. If all mineral lessees stipulated that the royalties were to be paid on the coal excavated, as shown by the measurements made by surveyors, greater care would in many cases be exercised to extract all the available coal, and the loss incurred in the extraction of pillars would be reduced to a minimum.

In shaft-sinking, boring, and other mining operations many seams of coal are passed through which are not at present worth working, and no national record is kept of such seams. It would be an immense benefit to posterity if there was a Government Department for the inspection of the systems of working coal, with powers to obtain and preserve complete records of all shafts and bores, and with a certain amount of control over the workings, so as to prevent the wanton sacrifice of national interests to individual profits.

APPENDIX I

TABLE SHOWING OUTPUT OF COAL FROM EACH COUNTY IN SCOTLAND SINCE 1878

Date.	Renfrew.	Stirling.	Clackmannan.	Edinburgh.
1878	163,450	944,436	...	725,122
1879	134,872	967,855	...	758,371
1880	108,205	1,000,043	...	793,804
1881	89,351	1,084,467	...	938,615
1882	114,324	1,153,389	...	850,423
1883	119,989	1,192,284	...	829,292
1884	121,732	1,182,891	...	811,252
1885	87,817	1,147,625	...	669,872
1886	45,897	1,134,294	...	738,296
1887	40,348	1,196,866	...	799,064
1888	51,996	1,360,722	344,113	767,311
1889	48,391	1,377,802	352,146	860,840
1890	58,351	1,408,085	402,733	868,878
1891	90,073	1,606,360	444,176	883,806
1892	74,212	1,745,235	412,489	928,721
1893	80,249	1,635,595	410,409	872,630
1894	49,263	1,421,872	297,691	820,681
1895	51,912	1,903,278	404,493	1,076,621
1896	45,957	1,986,142	329,580	1,096,956
1897	42,056	2,143,286	341,798	1,144,511
1898	36,092	2,259,058	345,632	1,244,747
1899	12,491	2,269,992	366,697	1,267,521
1900	13,104	2,322,676	424,696	1,329,495

Date.	Argyll. Dumfries.	Ayr.	Dumbarton.	Lanark.
1878	105,596	3,184,429	210,520	9,937,255
1879	107,111	3,203,052	216,282	9,385,920
1880	113,411	3,106,965	234,556	10,026,999
1881	113,012	3,378,843	249,250	11,925,644
1882	112,534	3,266,992	219,432	11,704,557
1883	120,036	3,276,993	222,471	12,208,715
1884	110,453	3,223,167	228,110	12,178,456
1885	105,733	3,180,101	219,910	12,233,289
1886	113,800	3,060,120	220,343	11,414,904
1887	112,062	2,995,904	292,403	12,026,534
1888	106,059	3,039,804	274,956	13,049,386
1889	102,810	3,120,362	327,624	13,160,304
1890	106,128	3,159,727	339,559	13,584,770
1891	100,348	3,385,977	366,176	13,400,360
1892	95,779	3,579,216	434,786	15,252,977
1893	103,776	3,325,934	437,541	13,926,446
1894	117,435	2,590,434	400,339	12,226,260
1895	113,945	3,667,201	544,465	15,922,772
1896	127,122	3,565,729	494,861	15,705,301
1897	141,732	3,585,427	499,975	15,822,297
1898	156,876	3,753,694	521,263	16,142,580
1899	154,786	3,809,313	511,199	16,416,754
1900	155,589	4,042,509	535,981	17,174,247

Date.	Fife.	Haddington.	Linlithgow.	Kinross, Perth, Peebles, and Sutherland.[1]
1878	1,676,901	221,639	394,721	273,213
1879	1,726,701	233,276	464,823	271,664
1880	1,930,511	243,302	448,955	268,090
1881	2,023,810	246,341	504,388	269,384
1882	2,052,732	250,899	507,204	282,648
1883	2,174,555	230,913	553,045	297,503
1884	2,114,588	227,550	662,046	326,443
1885	2,291,509	265,701	720,268	366,761
1886	2,295,926	250,600	738,892	360,406
1887	2,585,412	261,310	759,330	415,653
1888	2,459,395	255,455	663,944	35,963
1889	2,761,616	276,616	775,440	53,665
1890	3,121,146	300,159	793,458	55,908
1891	3,314,497	278,677	856,132	4,484
1892	3,587,602	296,995	778,576	5,344
1893	3,621,706	333,101	731,410	4,321
1894	3,784,019	248,334	630,680	4,635
1895	3,911,253	325,623	866,539	4,601
1896	3,633,455	352,920	882,961	5,619
1897	4,077,818	380,728	896,942	6,426
1898	4,447,569	410,740	910,331	7,803
1899	4,927,489	450,588	948,748	7,034
1900	5,419,373	464,755	1,184,092	45,587

[1] Includes Clackmannan up till 1887.

APPENDIX II

TABLE SHOWING OUTPUT OF COAL SINCE 1854

Date.	Scotland.	United Kingdom.	Date.	Scotland.	United Kingdom.
1854	7,448,009	64,500,000	1878	17,837,282	132,612,063
1855	7,325,000	64,307,459	1879	17,469,927	133,720,393
1856	7,500,000	66,508,815	1880	18,274,886	146,969,409
1857	8,211,473	65,274,047	1881	20,823,055	154,184,300
1858	8,962,249	64,887,899	1882	20,515,134	156,499,977
1859	10,300,000	71,859,465	1883	21,225,797	163,737,327
1860	10,900,500	79,923,273	1884	21,186,688	160,757,779
1861	11,081,100	85,512,144	1885	21,288,586	159,351,418
1862	11,076,000	83,510,838	1886	20,373,478	157,518,482
1863	11,100,500	88,165,465	1887	21,484,976	162,119,812
1864	12,400,000	92,962,873	1888	22,319,104	169,935,219
1865	12,650,000	98,150,587	1889	23,217,163	176,916,724
1866	12,625,000	101,501,794	1890	24,278,589	181,614,288
1867	14,125,943	104,375,480	1891	25,323,818	185,479,126
1868	14,709,959	103,014,207	1892	27,191,923	181,786,871
1869	14,417,150	107,299,634	1893	25,482,918	164,325,795
1870	14,943,553	110,431,192	1894	21,481,554	188,277,525
1871	15,438,291	117,352,028	1895	28,792,693	189,661,362
1872	15,383,609	123,497,316	1896	28,326,600	195,361,260
1873	16,857,772	128,680,131	1897	29,082,990	202,130,000
1874	16,788,661	126,590,108	1898	30,237,295	202,055,000
1875	18,597,507	133,306,485	1899	31,142,612	220,085,368
1876	18,665,612	134,125,166	1900	33,112,104	225,181,300
1877	18,320,074	134,179,968			

APPENDIX III

NOTE ON BANTON COAL-FIELD BY MR. H. M. CADELL OF BANTON AND GRANGE

The north-west side of the Banton basin is formed by the outcrop of the Hosie Limestones under the Smithy Coal, and farther back these beds are abruptly cut off by the large upthrow to the north which brings the trap rocks of the Campsie Hills up against all the coal-bearing strata, and terminates all the productive measures in that direction.

The large fault that bounds the Banton basin on the south throws down the strata in that direction, and brings the intrusive basalt sheet that has invaded the higher beds in this district against the edges of the Main Coal and Ironstone Seams at Low Banton. This intrusive whinstone, which is quarried at Kilsyth, has been bored through at various places, and there is no doubt that by sinking through it the Banton ironstones and coals can still be reached on the south side of the fault, but at a greater depth than in any part of the upper or northern basin. In one bore, made near Banton church, in 1885, the whinstone was found to be nearly 46 fathoms thick, but not very hard. At a depth of 68 fathoms the pavement of the Garibaldi section was reached, showing this seam to have the following dimensions:—

		Ft.	Ins.
Roof	Ironstone	0	3½
	Sandstone	0	8
Seam	Coal	0	1
	Ironstone	0	8
	Parting	0	1
	Ironstone and Fake	0	7
	Black Blaes	1	11
	Ironstone	1	0½
		4	4½

The Banton Black-band Seam, 14 inches thick, was reached at 85½ fathoms, and the Main Coal, 3 feet 7 inches, at 90 fathoms, showing that although this part of the field has not hitherto been worked, there is no reason to suppose the upper basin comprises all that is workable.

The Banton estate and its ironstone-field was purchased about the year 1767 by Mr. William Cadell, of Carron-park, the original managing partner of the Carron Company, in order to supply the Ironworks with good stone in the early and struggling days of that great concern, when the company was in straits for capital and needed careful nursing to avert impending ruin. The Carron Company obtained stone from this field at different times extending over more than a century, and old Mr. Cadell's prognostications as to its value were more than realized by subsequent generations. The Carron Company acquired for themselves at a subsequent date the part of the ironstone basin lying to the east of Banton estate, and exhausted all that was then considered workable in the district, but there is reason to believe a good deal of ironstone can still be profitably mined there. The minerals were at first carted, and subsequently taken by rail, down to the Forth and Clyde Canal for shipment to Carron; but all the pits were closed over twenty years ago, and the workings in one of the oldest ironstone-fields in Scotland were suspended for the time being. Since then the Kilsyth and Bonnybridge railway has been run right through the ground, and, with more modern appliances for pumping and deep sinking than were used formerly, a few hundred acres of good ironstone and coal may still be won, and the life of the Banton field prolonged for perhaps another generation.

The following is the approximate general section of the Banton mineral field, the upper part of which from the surface to the Main Coal is taken from No. 5 Pit, in the centre of the basin, and the lower part from borings and measurements of the strata in natural exposures.

SECTION OF BANTON BASIN

	Ft.	Ins.		Ft.	Ins.	Depth Ft.	Depth Ins.
Surface and Various Strata				105	0	105	0
No. 1 Clay-band Ironstone	0	2	Thickness of Clay-band Ironstone Section	30	6	135	6
Blaes	0	6					
No. 2 Clay-band Ironstone	0	8					
Blaes	5	0					
Nos. 3 and 4 Clay-band Ironstone	0	6					
Blaes	8	0					
No. 5 Clay-band Ironstone	1	2					
Parting	0	1					
No. 6 Clay-band Ironstone	0	4					
Blaes	3	0					
No. 7 Clay-band Ironstone	0	9					
Blaes	7	0					
No. 8 Clay-band Ironstone	0	3					
Blaes	2	0					
No. 9 Clay-band Ironstone	1	1					
Various Strata				120	0		
Black-band Ironstone, 14 ins. to				0	9	256	3
Various Strata				42	0		
Finestone (Ironstone)				0	7	298	10
Various Strata				22	9		
Craw Coal				1	3	322	10
Various Strata				24	0		
Main Coal, 4 ft. to...				3	6	350	4
Various Strata				12	0		
Fine Coal				1	1	363	5
Various Strata				226	11		
Banton Thick Smithy Coal				1	2	591	6
Various Strata				12	0		
Banton Thin Smithy Coal				0	9	604	3
Strata (Sandstone and Fakes)				107	6		
Coarse Ironstone				0	10	712	7
Strata (Blaes and Fakes)				52	6		
Ironstone				0	5	765	6
Strata (Blaes and Fakes)				51	0		
Limestone (Hosie's)				3	3	819	9
Blaes				12	0		
Limestone (Hosie's)				2	3	834	0
Strata (Sandstone and Fakes)				57	3		
Fireclay				4	0		
Smithy Coal				0	9	896	0
Sandstone in beds				23	0		
Blaes				10	0		
Limestone				4	0		
Strata (Blaes and Sandstone)				11	0		

	Ft.	In.	Depth Ft.	Depth In.
Ironstone Rib, 1½ in., on Coal, 3 ins.	0	4½		
Blaes and various Strata	75	0		
Ironstone	0	4		
Blaes	1	0		
Ironstone	0	3½	1021	0
Strata, Various	150	0		
Blaes and Ball Ironstone	27	0		
Limestone (Hurlet)	1	8		
Blaes	2	6		
Limestone (Hurlet)	6	0	1208	2
Depth to Limestone	1208	2		

APPENDIX IV

Messrs. James Nimmo & Co., Limited, have kindly supplied me with the following journal of the bore put down by them at Gartsherrie:—

DIAMOND DRILL BORE PUT DOWN ON GARTSHERRIE LANDS, NEAR GARTCLOSS PIT, DUE SOUTH OF SAID PIT, AND CLEAR OF NINETY-FATHOM DYKE ON THE SHALLOW SIDE OF SAID DYKE IN MOSS NEAR RAILWAY BRANCH TO THE EAST SIDE.

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Moss	3	3	0			
Clay	1	4	0			
Soft Fakes	0	4	0			
Soft Sandstone	0	1	6			
Fakes	1	3	0			
Fakes and Blaes	1	3	3			
Blaes	0	1	9			
Fakes	0	5	8			
Fakes	0	2	6			
Coal Blaes	0	1	3			
Fakes	0	3	4			
Fakes and Sandstone... ...	0	2	9			
Hard Sandstone	0	0	7	12	0	7
Hard Sandstone	0	0	8			
Fakes and Blaes	1	0	9			
Coal (Drumgray or Barmoral ...	0	2	6	13	3	11
Blaes	0	4	6			
Fakes and Sandstone... ...	0	2	3			
Blaes	0	4	6			
Sandstone	0	2	4	16	0	1
Sandstone	0	2	6			
Sandstone and Fakes... ...	2	1	0			
Dark Blaes	0	1	9	18	5	4
Dark Blaes	0	0	5			
Sandstone	0	0	6			
Foul Coal	0	0	4			
Fakes and Fireclay	0	2	9			
Dark Blaes	0	4	11			
Sandstone	0	0	8			
Blaes	0	0	10			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fakes	0	1	2			
Blaes streaked with Coal	0	0	4			
Sandstone	0	3	4			
Blaes and Ironstone Balls	0	3	0			
Blaes	0	4	3	22	3	10
Blaes	0	3	0			
Blaes and Balls	0	2	0			
Fakes and Sandstone	0	1	0			
Blaes	0	1	2			
Blaes streaked with Coal	0	0	3			
Fakes and Sandstone	2	5	1	26	4	4
Sandstone	3	0	0	29	4	4
Sandstone	3	1	0			
Fakes and Blaes	0	3	0	33	2	4
Fakes and Blaes	0	2	6	33	4	10
Sandstone	0	4	9			
Coal and Blaes	0	0	4			
Sandstone	22	1	1			
Blaes	0	3	3			
Coaly Blaes	0	0	4			
Blaes	1	3	6			
Fakey Sandstone	0	1	6			
Reddish Sandstone	0	2	0			
Fakes, Mixed	2	5	0			
Fakey Sandstone	0	1	6			
Blaes	0	2	0			
Furrey Fakes	0	5	6			
Coal and Blaes	0	0	4			
Blaes	0	2	3			
Sandstone	0	2	4			
Blaes	0	2	3			
Sandstone	2	3	1	67	3	10
Fakey Sandstone	1	3	6			
Blaes	0	0	6			
Fakey Sandstone	0	0	6	69	2	4
Blaes	0	2	10			
Fakes and Sandstone	0	3	6			
Sandstone	1	5	8	72	2	4
Sandstone	4	0	0			
Sandstone	0	2	0			
Blaes	0	3	6			
Sandstone	1	1	0			
Fakes and Sandstone	0	3	6			
Blaes	0	5	0			
Fakes and Fireclay	0	2	0			
Fakes and Blaes	0	5	3			
Fakes and Sandstone	1	1	3			
Blaes	0	1	3			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Coal	0	0	3			
Fakes and Sandstone	1	1	6			
Blaes	0	1	0			
Fakes and Sandstone	0	0	6	84	0	4
Sandstone	0	4	0			
Fakes and Sandstone	0	2	0			
Blaes	0	2	3			
Fakes and Sandstone	1	4	9			
Blaes	0	5	0			
Fakes and Sandstone	0	2	6			
Blaes	0	1	3			
Fakes and Sandstone	0	4	0			
Fakes and Blaes	0	3	3			
Blaes	1	1	9	91	1	1
Blaes	0	2	3			
Blaes and Balls	0	1	3			
Blaes	0	2	0			
Sandstone	6	3	9			
Sandstone and Plies	3	2	0			
Fakes and Sandstone	2	5	9			
Blaes	0	2	0			
Fakes and Blaes	1	0	0	106	2	1
Dark Fakes	2	2	6			
Dark Blaes and Balls	2	5	0			
Limey Blaes	0	3	6			
Limestone	0	3	0			
Blaes	0	1	0			
Limestone	0	2	8	113	1	9
Blaes	0	2	0			
Force Coal	0	0	3			
Blaes	0	4	10			
Fakes	0	1	9			
Blaes and Fireclay	0	1	3			
Fakes and Sandstone	1	1	0			
Blaes	0	1	9			
Fakes and Sandstone	0	4	3			
Gray Sandstone	2	4	0	119	4	10
Fakes and Sandstone	2	3	0			
Fakes	0	4	0			
Blaes	1	0	3			
Fakes	0	3	9			
Sandstone	4	3	6			
Sandstone and Plies	1	4	0			
Fakes and Sandstone	1	1	6			
Fakes	2	2	0			
Blaes and Balls	3	0	0	137	2	10
Blaes and Balls	3	2	9			
Limey Fakes	0	2	2			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Coal	0	0	4			
Fakey Sandstone	0	1	10			
Sandstone	1	5	0	143	2	11
Sandstone	0	0	6			
Fakes and Sandstone	0	3	6			
Blaes	0	3	9			
Foul Coal	0	0	5			
Fakes and Sandstone	0	1	2			
Blaes	0	1	0			
Blaes	0	3	6			
Fireclay	0	4	0			
Fakes and Sandstone	0	2	3			
Blaes	0	5	9			
Fakes and Blaes	0	2	9			
Fakes	0	2	5			
Fakes and Sandstone	0	2	0			
Blaes	0	2	6			
Fakes and Sandstone	1	1	9			
Sandstone	0	1	0	150	5	2
Sandstone	0	2	6			
Fakes and Sandstone	0	3	0			
Coal	0	0	3			
Fakes	0	2	3			
Blaes	0	1	3			
Coal	0	0	5			
Fakey Sandstone	1	0	0			
Fakes	0	2	9			
Coal, Parrot	0	0	4			
Fakes	0	1	10			
Blaes	0	1	0			
Fakes and Sandstone	2	5	0			
Sandstone	2	1	0			
Blaes and Balls	1	1	3			
Limestone	0	1	2			
Blaes and Balls	0	3	4	161	2	6
Blaes and Balls	0	1	6			
Limestone	0	1	3			
Blaes	1	0	9			
Coal	0	0	2			
Blaes	0	0	6			
Sandstone	0	4	10			
Fakes and Sandstone	2	3	0			
Blaes	0	1	6			
Foul Coal	0	0	8			
Blaes and Coaly Strains	0	4	0			
Sandstone	1	5	7			
Blaes	0	2	3	169	4	6
Blaes	0	4	0			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fakes	0	2	6			
Coal	0	0	3			
Sandstone	0	5	6			
Blaes	0	2	3			
Sandstone	0	5	6			
Fakes	0	0	9			
Sandstone	0	1	3			
Fakes	0	2	0			
Sandstone, coarse	4	5	0			
Sandstone	1	1	0			
Sandstone, coarse	1	1	9			
Sandstone	1	0	0			
Sandstone, coarse	1	4	0	183	4	3
Sandstone, coarse	2	3	6			
Sandstone	2	2	9			
Sandstone, coarse	0	0	9			
Fakes and Blaes	0	1	0			
Sandstone	0	2	0			
Fakes and Sandstone	0	2	9			
Blaes	0	2	9			
Fakes and Sandstone	1	0	6			
Fakes	1	0	0			
Sandstone	0	3	6			
Fakes and Sandstone	2	5	6	195	5	3
Fakes and Sandstone	0	5	0			
Fakes	1	3	0			
Blaes	1	2	0			
Limey Blaes	0	0	6			
Limestone	0	4	0	200	1	9
Limestone	0	2	8			
Coal	0	0	2			
Blaes	0	0	6			
Fakes	0	2	4			
Fakes and Sandstone	1	1	6			
Sandstone	2	0	3			
Fakes	0	1	4			
Sandstone, coarse	0	5	6			
Sandstone	1	5	6	207	3	6
Sandstone, coarse	0	3	0			
Sandstone	0	4	6			
Sandstone, coarse	4	0	9			
Blaes	0	0	4			
Sandstone	0	2	10			
Fakes	0	0	6			
Sandstone	1	2	4	214	9	5
Sandstone Plies and Fakes	1	3	6			
Fakes	0	1	0			
Blaes	0	5	6			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fakes and Sandstone	0	1	9			
Blaes	0	1	0			
Sandstone	0	5	6			
Sandstone Plies and Fakes	1	2	0			
Fakes and Blaes	0	1	3			
Coal	0	0	9			
Blaes	0	0	4			
Fakes and Sandstone	0	2	2	221	0	6
Fakes and Sandstone	0	2	0			
Sandstone	0	4	0			
Fakes and Sandstone	0	1	9			
Sandstone	0	3	0			
Blaes	0	4	9			
Sandstone	0	0	7			
Blaes and Iron Ribs	0	1	4			
Fakes and Sandstone	0	2	4			
Blaes	0	5	10			
Iron Rib	0	0	2½			
Limestone	0	0	9			
Fireclay and Blaes	0	0	6			
Fakes	0	2	6			
Coal Blaes	0	0	6			
Blaes	0	1	1	226	1	7½
Blaes	0	0	8			
Fakes	0	0	7			
Blaes	0	0	8			
Fakes	0	1	3			
Blaes	0	1	7			
Sandstone	0	1	0			
Fakes and Sandstone	0	2	6			
Blaes	0	3	6			
Blaes and Iron Rib	0	4	0			
Fakes and Sandstone	0	4	10			
Blaes	0	1	9			
Coaly Blaes	0	0	7			
Blaes	0	0	8			
Sandstone	1	1	3			
Fakes	0	3	0			
Blaes and Iron Rib	0	3	6			
Coal	0	1	9			
Blaes	0	2	6			
Fakes and Sandstone	0	2	3			
Blaes	0	0	5			
Fakes	0	1	6			
Blaes	0	1	4			
Limey Fakes	0	0	4			
Shaley Blaes	0	0	2			
Coal	0	1	7			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fakes and Sandstone	0	5	7	236	0	11½
Fakes and Blaes	0	4	9			
Iron Rib	0	0	4			
Coaly Blaes	0	0	8			
Sandstone	0	7	10			
Fakes and Blaes	0	1	9			
Fakes and Sandstone	0	1	9	239	0	0½
Sandstone	0	4	3			
Fakes and Sandstone	0	5	3			
Blaes	0	1	9	240	5	3½
Blaes	0	1	9			
Coal	0	0	5	241	1	5½
Fakes and Sandstone	0	7	10			
Blaes	0	2	0	242	5	3½
Blaes	0	1	0			
Fakes and Sandstone	0	8	9			
Coaly Blaes	0	0	4			
Fakes and Sandstone	0	2	5	245	0	3½
Fakes and Sandstone	0	0	9			
Coal and Blaes	0	0	6			
Blaes	0	1	3			
Fakes and Sandstone	0	4	3			
Fakes	0	4	0			
Sandstone	0	1	3	247	0	3½
Fakes and Sandstone	1	1	3			
Blaes	0	2	6			
Ironstone Rib	0	0	2			
Blaes	0	0	3			
Coal	0	0	10	247	4	0½
Sandstone	0	1	0	249	0	3½
Sandstone	2	0	0	251	0	3½
Sandstone	0	3	6			
Blaes	0	1	9			
Coal	0	0	4	251	5	10½
Blaes	0	1	6			
Fakes and Sandstone	0	2	2			
Blaes and Ironstone Rib[1]	0	5	6	253	3	0½
Blaes and Ironstone Rib	0	0	9			
Coal	0	0	3	253	4	0½
Blaes	0	0	9			
Coal	0	0	3	253	5	4½
Blaes	0	0	3			
Coal	0	0	3	253	5	10½
Fakes	0	4	0			
Sandstone	0	5	0			
Fakes	0	1	6	255	4	0½

---

[1] Three Ironstone Ribs in Blaes, and thickness of each was 2 inches, 1½ inch, and 1½ inch.

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Fakes and Blaes	0	2	9			
Blaes	0	3	6			
Coal	0	2	1	257	0	4½
Fireclay and Blaes	0	0	8			
Blaes	0	4	0			
Sandstone, Gray	0	6	3	258	5	3½
Sandstone, Gray	0	0	4			
Fakes and Blaes	0	3	3			
Fakes and Sandstone	1	0	2			
Blaes	0	2	6	260	5	6½
Blaes	0	2	6			
Coal, Parrot	0	0	1	261	2	1½
Blaes	0	0	3			
Fakes and Sandstone	0	3	6			
Coal and Blaes	0	0	9			
Sandstone	0	4	8	262	5	3½
Fakes	0	0	9			
Blaes	0	0	6			
Coal	0	0	3	263	0	9½
Fakes and Sandstone	0	3	0			
Blaes	0	2	3	264	0	0½
Blaes	0	2	0			
Fakes	0	2	3			
Fakes and Blaes	0	4	0			
Fakes and Sandstone	0	5	9			
Blaes	1	2	9	267	4	9½
Blaes	0	4	9			
Fakes	0	3	5			
Sandstone	0	3	0			
Fakes and Sandstone	2	2	1	272	0	0½
Blaes	0	2	0			
Kingle	0	0	6			
Sandstone	0	1	0			
Fakes and Sandstone	0	3	9			
Blaes	0	3	0			
Sandstone	0	0	5	273	4	8½
Sandstone	0	5	0			
Fakes and Sandstone	0	3	6	275	1	2½
Fakes and Sandstone	1	0	6			
Sandstone	2	2	10			
Fakes and Sandstone	0	5	0	279	3	6½
Fakes and Sandstone	1	0	0			
Fakes	0	4	0	281	1	6½
Fakes	0	1	3			
Blaes	2	2	6			
Ironstone	0	0	3			
Blaes	1	4	0	285	3	6½
Blaes and Ironstone Ribs	0	1	9			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Ironstone	0	0	5			
Blaes	0	1	4			
Blaes and Ironstone Ribs	0	4	6			
Blaes	0	2	3	287	1	9½
Ironstone	0	0	9			
Blaes	0	2	10			
Ironstone	0	0	5			
Blaes	0	0	10			
Ironstone	0	0	5			
Blaes	0	3	3			
Ironstone	0	0	6			
Blaes	0	0	9			
Ironstone	0	0	2			
Blaes	0	1	9			
Ironstone	0	0	2			
Blaes	0	1	6			
Ironstone	0	0	5			
Blaes	0	1	9			
Sandstone	0	7	3			
Fakes and Sandstone	0	1	3	291	1	9½
Fakes and Sandstone	0	2	0			
Blaes	0	1	3			
Fakes and Sandstone	0	5	3			
Fakes	0	2	0			
Blaes	0	1	0	293	1	3½
Blaes	0	2	0			
Fakes and Sandstone	0	3	6			
Sandstone	1	1	0	295	1	9½
Fakes and Sandstone	1	0	0			
Fakes and Blaes	0	5	0			
Blaes	0	4	0			
Fakes	0	1	3	298	0	0½
Coaly Blaes	0	0	3			
Blaes	0	2	0			
Coal	0	0	1	298	2	4½
Fakey Sandstone	0	0	4			
Coaly Blaes	0	0	3			
Fakey Sandstone	0	2	9	298	5	8½
Sandstone	1	1	8			
Fakes and Sandstone	0	3	6			
Blaes	0	1	6	301	0	4½
Blaes	1	2	0			
Ironstone	0	0	3½			
Blaes	0	0	4	302	3	0
Coal	0	1	4	302	4	4
Coaly Blaes	0	0	5			
Blaes	0	2	1			
Ironstone	0	0	8			

	Fms.	Ft.	Ins.	Fms.	Ft.	Ins.
Blaes	0	4	3	303	5	9
Blaes	0	6	10			
Fakes	0	0	4			
Blaes	0	1	5			
Fakes	0	0	8			
Coal	0	1	3	305	4	3
Fakes	0	0	10	305	5	1
Fakes	0	0	4			
Fakes and Sandstone... ...	1	0	9			
Blaes	0	1	0			
Iron Rib...	0	0	2			
Blaes	0	1	6			
Limey Fakes	0	0	7			
Blaes	0	1	0	307	4	5
Blaes	0	2	9			
Limey Fakes	0	0	3			
Blaes	0	1	8			
Limey Fakes	0	0	5	308	3	6
Blaes	0	3	0			
Coal	0	0	3	309	0	9
Fakes	0	2	0	309	2	9
Fakes	0	4	0			
Blaes	0	0	9	310	1	6
Blaes	0	1	3			
Coal	0	0	3	310	3	0
Fakes and Sandstone... ...	0	2	9	310	5	9
Fakes and Sandstone... ...	0	2	3			
Blaes	0	0	9			
Coal	0	0	6	311	3	3
Fakes and Sandstone... ...	0	1	0	311	4	3
Fakey Sandstone	0	3	6			
Fakes	0	1	3			
Fakey Sandstone	0	1	3	312	4	3
Fakey Sandstone	0	4	9	313	3	0

APPENDIX V

Section of the Coal Seams in the Wimbledon Pit, of the Campbeltown Coal Co., Limited. (Supplied by Mr. T. Lindsay Galloway.)

		Fms.	Ft.	Ins.
	Surface and Strata	10	0	10
	Coal (foul)	0	3	3
	Strata	5	0	3
	Coal	0	1	10
	Strata	1	1	5
Kilkiven Seam.	Coal	0	2	2
	Strata	0	5	10
	Coal	0	3	7
	Strata	2	4	10
	Coal	0	0	11
	Strata	13	2	9
Main Coal Seam.	Coal	1	1	6
	Fireclay parting	0	0	2
	Coal	0	4	3
	Coaly Blaes	0	0	8
	Coal, "Underfoot" (inferior)	0	3	6
		38	1	9

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